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A RAIL WEAR TESTING MACHINE.

THE machine illustrated was designed primarily to determine accurately the relative durability of the different varieties of steel rails made by the Pennsylvania Steel Company, such as Standard Bessemer steel rails, open-hearth high-carbon steel rails, and rolled Manard steel rails when used in tracks of maximum traffic on sharp curves.

As now developed it provides means for ascertaining valuable facts, not strictly relating to durability. The effects on rails and wheels of brakes and of slipping driving wheels can be observed under various conditions; the relative co-efficients of adhesion for different varieties of rails can be measured; the relative effectiveness of various types of rail points can be determined; the effect of flat-spotted car wheels on different varieties of rails can be observed; in fact, the usefulness of this machine and its effect on railroad maintenance are hardly yet realized.

Two 33-inch M. C. B. standard tread car wheels having independent axles are mounted in bearings on the revolving arm and carry the dead load of the arm and center steady pin. To reproduce the conditions and effects of driving wheels on a track, power is supplied directly to the wheels from the two motors mounted on the revolving arm. To reproduce the conditions of ordinary wheels, power is supplied to the revolving arm by motors at the base of the machine, the motors turning the arm through gearing attached to the center pin. The wheels are provided with air brakes. The circular track on which the car wheels run is about 20 feet in diameter. As exhibited before the American Railway Engineering and Maintenance of Way Association at Chicago, the track is composed of three equal lengths of A. S. C. E. 100-pound section rail, connected by standard fishing and fastened by the usual spikes to short wooden ties. The three rails are of different grades of steel and are painted red, yellow, and white, for easy distinction. The ties are secured to a heavy circular cast-iron frame tied by four radial arms to the center bearing. If desired, the rails can be fastened directly to the iron frame, which is so designed that even under these conditions a slight wave motion in the rail is perceptible.

The maximum speed at which the machine is designed to run is 85 revolutions per minute, which gives a train speed to the car wheels of 60.94 miles per hour. Intermediate speeds are used in practice to produce the conditions of freight or passenger traffic.

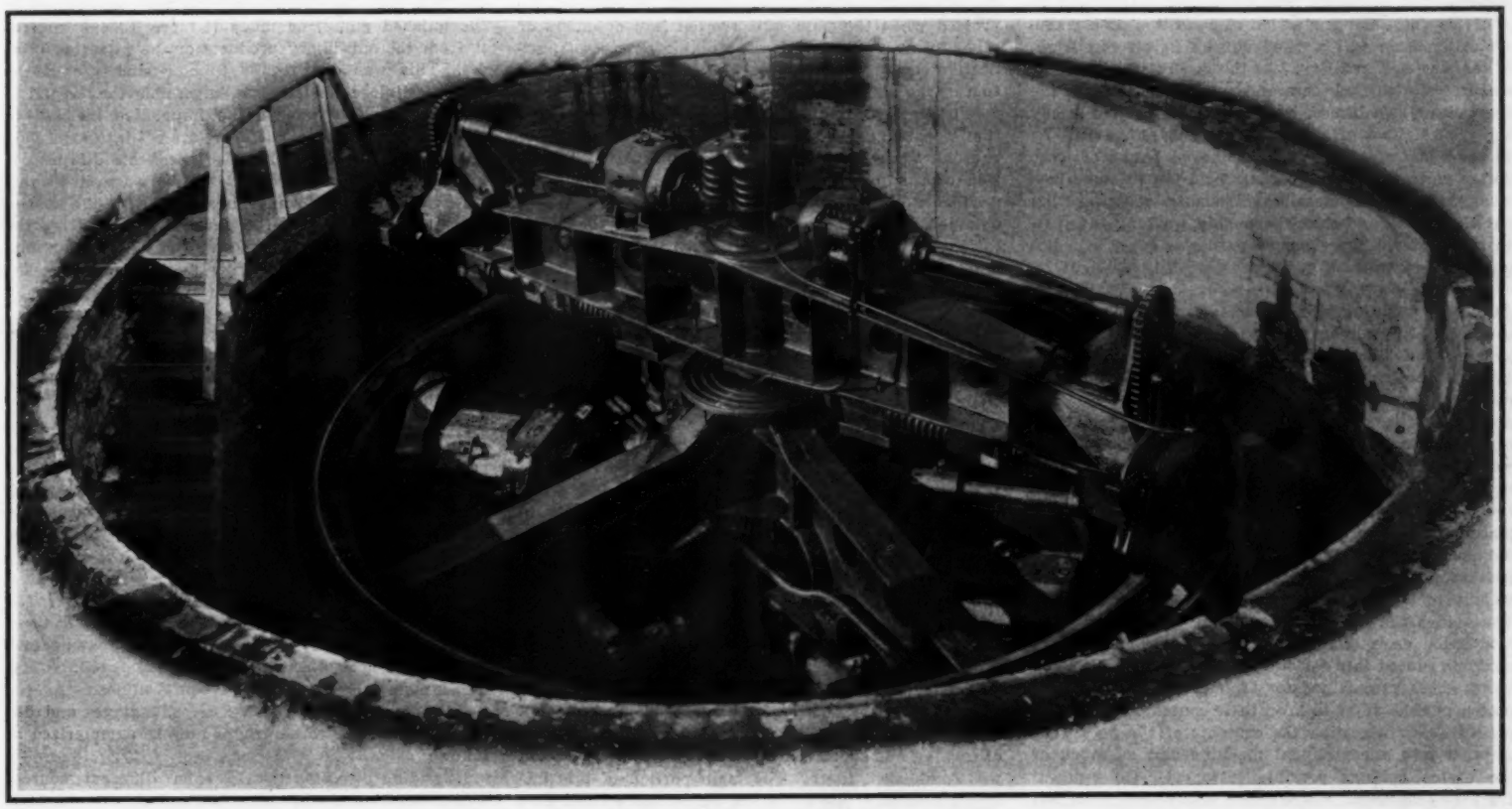
The vertical pressure exerted by each car wheel on the rail due to the dead load is 11,500 pounds; by adjustment of the springs mounted above the revolving arm this can be increased by any amount up to 300,000 pounds, making the maximum vertical pressure 41,500 pounds. A ball thrust bearing between the revolving arm and the springs eliminates largely the friction due to their pressure.

As sufficient end play is allowed the axles, there is also a lateral pressure on the head of the rail due to the centrifugal force of the wheel and axle. This varies from 450 pounds at 10 revolutions to 32,800 pounds at 85 revolutions. By adjusting the spring on each axle this can be increased by any amount up to 15,000 pounds. The maximum lateral pressure, therefore, which can be exerted by each wheel varies from 15,450 pounds at 10 revolutions to 47,800 pounds at 85 revolutions per minute.

Revolutions per Minute of Beam.	Train Speed of Wheels, Miles per Hour.	Centrifugal Thrust of Wheels, in Pounds.
10	7.17	450
15	10.75	1020
20	14.34	1820
25	17.92	2840
30	21.51	4080
35	25.09	5550
40	28.68	7260
45	32.26	9200
50	35.85	11300
55	39.43	13700
60	43.02	16300
65	46.60	19300
70	50.19	22500
75	53.77	25500
80	57.36	29000
85	60.94	32800

The tables of traffic over the Horse Shoe Curve of the Pennsylvania Railroad, one of the points of greatest main line traffic congestion in the United States, show that an average of 2,600 cars per day pass over each freight track at this point. This means that each rail in the track is subject to the wear from 10,400 wheels per day. A corresponding wear is given the rails in this machine, when running at 30 revolutions per minute, in less than three hours, and a week's wear shown in less than a day.

With the arm of this machine making 30 revolutions per minute, the wheels are traveling at a train speed of 21½ miles per hour, which is above the average speed of a freight train on the Horse Shoe Curve.



A RAIL WEAR TESTING MACHINE.

ELECTRICITY IN REFRIGERATION.

AN exhaustive description of various systems of electrical refrigeration is presented in the Journal of the Franklin Institute by R. L. Lloyd. A retail meat shop has a "baby" Larsen-Baker compressor operated by a 3-horse-power motor. The machine is set up in the basement under the meat box, the latter often holding 1½ tons of meat. This is a direct-expansion system with a brine tank auxiliary for storage. A combined wholesale and retail meat business has a large installation consisting of two 25-ton Vilter refrigerating machines, each driven by a 50-horse-power Northern motor, chain geared, one Triplex plunger brine pump driven by a 5-horse-power motor, one deep-well pump driven by a 3¾-horse-power motor, one large refrigerator box or cooler, and three smaller refrigerator boxes or freezers, one pickling room, and one brine tank. The system is brine circulation exclusively. A florist's shop is equipped with a Brunswick refrigerating machine of 1 ton capacity, and a saving of about 10 per cent is effected compared with the former practice of buying the ice. A dairy which handles 4,000 quarts of milk per day is equipped with an 8-ton Buffalo refrigerating plant driven by a 15-horse-power motor. The Horn & Hardart Baking Company have spent $275,000 on an up-to-date establishment, and the refrigerating plant is the best of its kind. It consists of two 8-ton units, belt-driven from a main shaft so arranged with clutch pulleys that one or both or neither can be operated at will. A 40-horse-power motor turns the shaft. A confectioner and ice cream maker has an equipment consisting of a 2-ton refrigerating machine, belt-driven by a 5-horse-power, 2-phase General Electric motor. Individual machines suitable for apartments or large residences are in the market, and make a very neat and compact arrangement. A motor of 1 horse-power is all that is needed.

GUNCOTTON AND ITS MANUFACTURE.*

AN ACCOUNT OF MODERN METHODS.

BY COL. SIR FREDERIC L. NATHAN, R.A.

GUNCOTTON was discovered early in 1846 by Christian Friedrich Schönbein, at Basle. It was not until forty years later that it fulfilled his expectations, referred to in a letter from him to Faraday, dated August 25th, 1846, "of becoming a dangerous rival to gunpowder," as regards its use as a propulsive explosive. Schönbein came to England in August, 1846, and was present at Woolwich on October 9th of that year when some successful experiments were made with his guncotton, and immediately afterward, he, together with Böttger, who independently discovered guncotton shortly after Schönbein, entered into negotiations with Messrs. John Hall & Son, of Faversham, for the manufacture and sale of guncotton in England. This firm erected a guncotton factory adjacent to their gunpowder works, but a very disastrous explosion on July 14th, 1847, destroyed the factory, which was never rebuilt.

The early history of the manufacture of guncotton abroad, and of the attempts made, particularly in Austria, to adapt it for propulsive purposes in small arms and cannon, have been so fully described by S. J. von Romocki in vol. ii. of his "Geschichte der Explosivstoffe," by Dr. R. Escales in "Die Schiessbaumwolle," and by others, that it is not proposed to deal with these matters in this paper. It is only necessary to remark that a factory was erected at Hirtenberg in Austria, where the production of guncotton on a manufacturing scale was worked out by Baron von Lenk, of the Austrian artillery. As the general principles he elaborated with such care and perseverance are in the main those still in use, it is of interest to give briefly the general lines of his processes of manufacture. As his raw material, von Lenk employed hanks of loose cotton yarn, purified by boiling for a few minutes in a weak solution of potassium carbonate, centrifugaling out the liquid, and then thoroughly washing the yarn in cold water. The cleansed yarn was dried in a hot air chamber; when dry, it was placed in air-tight receptacles to cool; when cool, it was immediately dipped in the nitrating acid. The nitrating acid consisted of 1 part by weight of nitric acid of 1.52 specific gravity, and 3 parts by weight of sulphuric acid of 1.84 specific gravity, thoroughly mixed together and cooled. The dipping pans containing the nitrating acid were of cast iron and stood in troughs surrounded by cold water. About 6 ounces of cotton, or two skeins, were immersed in the acid at a time, and moved about in it for a few minutes, until thoroughly saturated, the cotton was then removed by means of an iron fork, placed on an iron grating above the pan, and some of the excess acid got rid of by gentle squeezing, the proportion of acid retained being about 10.5 parts by weight to 1 part by weight of the original cotton. The acid bath was made up by the addition of fresh acid after each removal. Six to eight skeins were next introduced into a stoneware pot, fitted with a lid, in which they remained for 48 hours. The pots were placed in cold water to keep their contents cool. After the 48 hours' digestion the contents of the pots were emptied into a centrifugal machine and as much of the excess acid as possible extracted. On removal from the centrifugal machine the hanks were immersed as suddenly and completely as possible in a cascade of water, washed until no longer acid to the taste, and afterward placed in crates or perforated boxes and kept in flowing water for about three weeks. At the expiration of that time the skeins were centrifugaled to remove the bulk of the water, and boiled for 15 minutes in a solution of potassium carbonate of 1.02 specific gravity. The alkaline liquid was removed, and the skeins again immersed in flowing water for a few days.

Manufacture proceeded at Hirtenberg without serious accident until July 30th, 1862. On this day the guncotton in the magazines exploded, owing to spontaneous decomposition, and another serious explosion occurring on October 11th, 1865, the manufacture of guncotton was officially prohibited in Austria.

Early in 1863, by the desire of the Secretary of State for War, Sir Frederick Abel took up the study of guncotton and its manufacture in this country. In his first memoir on "Researches on Guncotton," read before the Royal Society on April 19th, 1866, Abel described the important steps in von Lenk's system of manufacture, mainly in connection with the production of a stable product. He was of opinion that the alkaline boiling was the most important part of the purification process, and that its function was not so much to neutralize and remove residual traces of the nitrating acid, as to dissolve unstable bodies produced by the action of the nitrating acid on small quantities of resinous and other foreign substances still retained by the tubular fiber.

The important modification introduced by Abel in the manufacture of guncotton and patented by him in 1865 (English Patent 1102), had for its object the reduction of guncotton to a pulp, and forming from this pulp grains suitable for propulsive purposes. But the "pulping" process had, he considered, a further advantage, which was described by him in the following words: "As the difficulties attending the perfect removal of the acid with which the guncotton remains impregnated after its conversion are mainly attributable to the tubular structure of the cotton fiber, and to the circumstance that the latter contracts considerably upon conversion into pyroxylin, the complete purification of the material is very greatly facilitated by reducing the guncotton fiber to a fine state of division, similar to that of the pulp used in paper manufacture, in which form it appears likely that guncotton will receive advantageous application. By submission to the 'pulping' process, the guncotton is divided into very minute fragments, and it is at the same time violently agitated for some considerable time with a very large volume of water (rendered slightly alkaline if necessary), which is afterward thoroughly expressed when the pulp is converted into cylinders or other forms, so that a more searching process of purification can scarcely be conceived than this disintegration of the guncotton."

It is very probable, in view of the system of purification, consisting mainly of prolonged washing in cold running water, in use at the time of Abel's introduction of the pulping process, that his treatment did produce a much purer guncotton than was formerly obtained, but recent work on the subject of the purification of guncotton has demonstrated that other points besides the complete removal of traces of the nitrating acids underlie the chemistry of the purification process. This important question will be dealt with later.

Although the pulping and granulating of guncotton did not succeed in transforming it into a propulsive explosive, the greater purity of the material resulting from the pulping process re-established confidence in guncotton for other military purposes, such as for mines, torpedoes, and field service work, as well as for blasting purposes.

Messrs. Prentice & Co., of Stowmarket, had commenced the manufacture of guncotton according to von Lenk's system in 1863, but a serious accident occurred at this factory not long after starting manufacture. In 1865 they rebuilt and enlarged their factory and recommenced the manufacture of guncotton, introducing Abel's improvements. The Stowmarket factory now belongs to the New Explosives Company, Ltd., and is still making guncotton by the Abel process.

The manufacture of guncotton was commenced in 1863 at Waltham Abbey on a small scale under Abel's direction; it was not until 1872 that a factory capable of turning out about 250 tons of guncotton per annum was established there. The main portion of this factory consisted of old buildings which had formed part of the saltpeter refinery, and abutted on the principal street of the town. Fresh land, away from the town, was acquired in 1885, and a guncotton factory was built on it, and commenced work in 1890. It was considerably enlarged and altered in 1904-5, and is now capable of producing about 2,000 tons of guncotton per annum by the displacement dipping process of manufacture, to be referred to later.

It has already been stated that the invention of Abel had for its object the production of guncotton in a form in which it was hoped it would be suitable for use as a propellant. To attain this object, he reduced the finished guncotton to a very fine state of division. It was subsequently found that guncotton in this condition was more readily purified than when it had to be kept in the form of skeins throughout all the processes of manufacture. Abel's process had other advantages, however. As the guncotton in its final form was reduced to a pulp, it was no longer necessary to use expensive long stapled cotton yarn, and instead of this material, waste from the cotton mills was employed; this waste cotton was, by means of suitable machinery, opened out, and in this condition it was more completely exposed to the action of the acids than were the skeins. Again, the guncotton pulp could, by hydraulic pressure, be compressed into dense and compact masses of any desired shape, making it much more suitable for use in mines, torpedoes, and for blasting purposes, and in this condition it could be stored wet for indefinite periods. This form of compressed guncotton was rendered more valuable still when it was discovered in 1869 by Mr. E. O. Brown, of the Chemical Department, Royal Arsenal, that it could be fully detonated in its wet condition and unconfined, by fulminate of mercury.

Guncotton compressed into slabs and disks is still the form of guncotton used for mines, for torpedoes, and in connection with demolition work in the field. The processes by which these slabs and disks are produced will be dealt with later.

The von Lenk process of manufacture, as modified and improved by Abel, is universally employed at the present day, except as regards the actual process of nitration. The modifications this process has undergone will be described when dealing with this particular operation.

Before considering the actual processes of manufacture, it is desirable to say a few words about the raw materials. The base of guncotton is cellulose. The purer the cellulose, the purer the guncotton and the better the yield, other things being equal. There is little doubt that the skeins of long stapled yarn used by von Lenk were of great purity, and were free from foreign substances generally. At the same time, the fact that the skein condition was maintained in the finished guncotton made it more difficult to free it from the subsidiary products of the nitration process. This was due to the tubular structure of the cotton cellulose rendering it impossible for the purification process to remove the impurities inclosed in the long fibers. When the fibers are cut into extremely short lengths in the pulping process, this difficulty is in a great measure overcome. Cotton waste in its raw state from the mills is anything but pure; but a special industry sprang up for the purpose of converting the ordinary mill waste into a condition suitable for guncotton making. The processes it undergoes are: degreasing by means of solvents, treatment with caustic soda, bleaching, and washing. The effect of these treatments, if properly carried out, is to produce a fairly pure resistant cellulose, and they have now been perfected to such an extent that there is no difficulty in obtaining cotton waste containing on an average not more than 0.2 to 0.3 per cent of matter soluble in ether, and having very little altered cellulose of the nature of oxy- or hydro-cellulose. Attempts have been made to find substitutes for cotton waste equally suitable, and, if possible, less expensive. This is a matter which has received some considerable attention at the Royal Gunpowder Factory. During the last few years various materials have been investigated, and guncotton made from them on a manufacturing scale. The materials so far tested may be divided into three groups: 1. Ordinary cotton waste and weaving mill waste. 2. Short fiber from the cotton used. 3. Fibrous materials other than cotton cellulose. As the results of experimental work the advantages and disadvantages of the three groups may be summarized as follows:

1. *Ordinary cotton waste* from different sources varies considerably in character, and this is not without effect on the resulting guncotton. Its chief disadvantage, however, is that it generally contains considerable quantities of wood and other foreign bodies. All these substances are possible sources of regions of low stability in the guncotton. On the other hand, it is plentiful, easily procured, and reasonably cheap, and it can be relied upon to produce a satisfactory guncotton as regards nitrogen content and percentage of soluble in ether-alcohol.

Weaving mill waste is a material composed entirely of woven cotton fabric of various natures, partly broken down by mechanical means. It differs materially in character, and, as at present in the market, is liable to contain, mixed together, both soft material and hard, stiff, starchy rags. It may also be overbleached, and contain an undue proportion of altered cellulose. In its best form it is pure cotton cellulose, remarkably free from foreign matters, and makes excellent guncotton. It is, however, apparently not procurable at present, in its best form, in anything like sufficient quantity, and its price would probably be considerably higher than the normal price of ordinary cotton waste.

2. *The short fiber from the cotton seed*, several samples of which, from different sources, have been experimented with, would no doubt make a good guncotton, if it could be obtained freed from particles of the seed husk. Unfortunately it does not appear possible to remove the husk particles entirely by mechanical

* Read before the Society of Chemical Industry.

means, and the fiber is therefore subjected to a very drastic chemical treatment, which, while it does not remove all the husk, produces non-resistant cellulose to a considerable extent, and the final product, in consequence, gives a guncotton low in nitrogen, and with a high percentage of soluble in ether-alcohol.

3. Certain fibrous materials which, when submitted to the chlorination method of Cross and Bevan for the estimation of cellulose, were found to give a high result, were selected for experiment. Among these were ramie fiber, *Marsdenia tenacissima*, to be found in certain parts of India, and *Asclepias semilunata*, which comes from Uganda. These materials contain ligneous matter, which, in the case of ramie, is present not as an incrustation, but forming a compound cellulose with the more resistant material, and difficult to remove completely on a manufacturing scale. Even when this ligneous material has been got rid of to a considerable extent, the fiber requires a much longer nitration and boiling to produce a correct and stable guncotton. Its price also is very high. *Marsdenia tenacissima*, by a simple treatment, easily carried out on the manufacturing scale, can be made into a fairly pure resistant cellulose, giving on nitration a distinctly promising guncotton. At present, however, it is not procurable in anything like sufficient quantity, and its price is unknown. *Asclepias semilunata* can also, by a simple process of purification, be reduced to a very highly resistant normal cellulose, capable, by slightly altering the nitration process, of being converted into a guncotton similar in its properties to that prepared from cotton cellulose. So far it has not been possible to obtain this material in quantity, and its price is also unknown.

So far, therefore, the best material which has come to light for the manufacture of guncotton is weaving mill waste, if the best form could be procured in sufficient quantity, at a reasonable price. Failing weaving mill waste, cotton waste as used since the early days of guncotton manufacture still remains the best commercial form of raw material.

The nitric and sulphuric acids universally employed are commercial products of a fairly high standard of purity. It is essential that they should not contain solid impurities which might adhere to the guncotton, and which would certainly interfere with the recovery of the waste acid. Of recent years it has been possible to obtain Nordhausen sulphuric acid at a fairly reasonable price, and its use has enabled a larger proportion of waste acid to be revivified than was possible when ordinary sulphuric acid only was available. It is a common practice now for explosives factories to manufacture their own nitric acid, and to revivify and recover their waste acids, and most of them possess installations of considerable size for carrying out these processes, and for mixing the two acids on a large scale. These matters hardly come within the scope of the present paper, however, even if time permitted. Before these installations existed, it was the practice to buy acids of a certain strength and mix them in the proportion of 3 parts by weight of sulphuric acid to 1 part by weight of nitric acid; now, the more correct system is being adopted of mixing large quantities, analyzing the mixture, and adjusting the composition of the mixed acid by the addition of nitric or sulphuric acid, so as to obtain the correct percentage composition. The nitrating acid is, of course, made up of a certain proportion of waste acid to which new nitric acid and new sulphuric acid are added.

The manufacture of guncotton comprises the mechanical processes in connection with the preparation of the cotton waste, the chemical processes of nitration and purification, and the final mechanical operations of pulping and washing.

TEASING.

Cotton waste as supplied to the factory contains a notable percentage of hygroscopic moisture, also wood, pieces of iron, metal, string, rubber, etc. These impurities are removed as far as possible by hand picking, and the cotton is then passed through what is known as the teasing machine, which, by means of a combination of rollers, armed with iron teeth, separates the fiber of the cotton and opens out knots and lumps. As the cotton leaves the machine, it is picked over again. It was formerly the practice to cut the teased cotton in a description of guillotine into 3-inch squares. This operation was one of the features of the original Abel process, but it has been disused of late years at Waltham Abbey, because it was found that the cotton along the cut edges was felted to such an extent as to resist the action of the nitrating acid.

DRYING.

At Waltham Abbey the cotton, as it leaves the teasing machine, is delivered on to an endless band, which carries it to the drying machine. The moisture is expelled from the cotton by a blast of hot air, supplied by a fan through a steam heater. The cotton waste passes very slowly through the machine, the operation lasting about three-quarters of an hour, and issues from it containing about half a per cent of moisture. It is immediately weighed out into charges and placed in sheet iron boxes or other suitable receptacles with lids, to cool, for which a period of about 8 or 9 hours is sufficient. During the cooling the cotton waste reabsorbs about half a per cent of moisture. The object of removing the moisture from the cotton waste is to prevent dilution of the nitrating acid. The above is a typical method of drying, but it is obvious that this simple operation can be effected in other ways.

NITRATION.

In von Lenk's system of manufacture the operation of nitration was carried out in two stages. The first stage was the dipping of the cotton in mixed acid contained in nitrating pans; and the second, the completion of the nitration by allowing the partially nitrated cotton to remain in contact with a weaker acid, in earthenware pots, for a prolonged time. The loss of guncotton caused by occasional decompositions in the digesting pots and the labor entailed in handling them were undoubted disadvantages, and led some manufacturers to revert to the even older method of completing the operation in one stage. In this system, which has been called the direct dipping process, the size of the nitrating pans was reduced to enable them to be lifted on to trucks, wheeled to the acid centrifugals and their contents tipped into them.

From this process it was but a short step to a method which has been adopted to a large extent on the Continent, and known as the nitrating centrifugal method of nitration. Instead of nitrating in pans and tipping into the centrifugal machine, the operations of nitration, digestion, and removal of the acid are all carried out in the centrifugal machine itself. In this way labor is economized, and it is claimed fewer decompositions occur and that therefore a higher yield is obtained.

It will be seen that the improvements in methods of nitration so far enumerated are of the nature of modifications of the original process such as characterize the gradual evolution of almost every manufacturing operation. The next noteworthy improvement, however, marks an entirely new departure. The inventors of the displacement system of nitration, Messrs. J. M. Thomson and W. T. Thomson, of the Royal Gunpowder Factory, Waltham Abbey, have discarded the older methods entirely, and introduced a system founded on new principles.

Before describing the displacement method, it is necessary to give a somewhat detailed account of the various processes preceding it, referred to above. It is not, however, necessary to refer to details of the earlier nitration processes, and the method of nitration used by von Lenk has been sufficiently described. The Abel nitration process, which followed very closely on the lines of von Lenk's process, was the one universally employed from about the year 1865 until comparatively modern times, and as it is still in use in many factories both in this country and abroad, it will be described in detail as formerly carried out at Waltham Abbey.

The nitrating acid was composed of three parts of sulphuric acid of 96 per cent mono-hydrate to one part of nitric acid of 91 per cent mono-hydrate, thoroughly mixed and cooled. This acid was run from the store tanks into cast iron dipping pans, holding about 220 pounds each, the pans being supported in an iron tank through which cold water circulated, to keep the temperature below 70 deg. F. The dipping pans were provided at the back with gratings, on which to press out some of the acid from the charge. The charge of cotton waste weighed 1 pound 4 ounces, and on removal from the cooling box was passed from the back through an earthenware pipe in the partition running along the back of the pans, and raked by a dipper, as rapidly as possible, into the acid. After remaining in the acid bath for about eight minutes, the cotton was removed to the grating and a portion of the acid squeezed out by means of an iron lever having an iron plate attached to one end. After a charge had been removed from the dipping pan about 13¾ pounds of the mixed acid was run into it to replace the amount removed with the charge. The charge, now weighing with the adhering acid about 15 pounds, was placed in an earthenware pot provided with a cover and transferred to the cooling pits, through which a stream of cold water flowed, and where it remained for 12 hours. During this period of digestion the conversion of the cotton into guncotton was completed. The contents of the pots were now emptied into a centrifugal wringing machine, and the bulk of the waste acid extracted. The guncotton was then removed from the centrifugal machine and placed in galvanized iron pans with long handles. These pans, when filled, were carried quickly across to the immersing tank and the guncotton thrown into a large bulk of water, the workmen standing by the tank and pushing the guncotton at once under the water with stout wooden paddles. The immersing had to be done as quickly as possible, as, if the guncotton were allowed to come gradually in contact with water, it was liable to fume off. The immersing tank was fitted with a perforated copper plate, to allow the water to overflow, so that fresh water was constantly passing through the tank. The guncotton was kept well stirred by means of a wooden paddle. When 2 hundredweight had been immersed, the inflow of water was stopped and the tank drained down. When all the water had been run off the tank was filled up again with fresh water. This was repeated six times or until the guncotton no longer tasted acid. When this stage had been reached the guncotton was wrung in a centrifugal machine, water from a hosepipe being turned on the guncotton for one minute during the wringing, and it was then ready for boiling.

This process, although it undoubtedly produced a good guncotton, had certain disadvantages, and the amount of labor required was very great. The plant, although individual items were not expensive, very rapidly deteriorated, and the cost of renewals and replacements was heavy. Power was required to drive the centrifugal machines, large quantities of water were used both for cooling and immersing, and decompositions, both in the pans, pots, and acid centrifugals, were by no means an infrequent occurrence.

(To be continued.)

IMITATION PARCHMENT PAPER.

MOST of the artificial or imitation parchment papers are made from sulphite cellulose, or pulp, with additions of glue and sulphate of alumina, the sulphite cellulose made according to Mitcherlisch's process, owing to its long, strong fibers, being best adapted for the purpose. Other manufacturers use a mixture of sulphite cellulose and straw pulp, also sized; others again use sulphite cellulose without size, but add a little sulphuric acid in the Holland engine. The following recipes have been successfully employed in practice:

I. 60 per cent sulphite cellulose, 25 per cent soda cellulose, 15 per cent wood pulp. Fully sized, 4 parts size, 5 parts sulphate of alumina to 100 parts of dry stuff. The paper is admittedly good, but not of the best quality.

II. 100 per cent sulphite cellulose, fully sized; 5 parts each of glue and sulphate of alumina to 100 parts of dry stuff. The result is the ordinary parchment paper imitation.

III. 100 per cent sulphite cellulose II, 2 parts of sulphuric acid diluted with water, are added to each 100 parts of dry stuff in the Holland engine. The paper made from second quality sulphite cellulose is of coarse appearance, but is very much like parchment.

IV. 60 per cent of sulphite cellulose, 40 per cent of straw pulp, 4 parts size, and 4 parts sulphate of alumina to 100 parts of dry stuff. A very bright colored paper, clearly translucent.

V. 60 per cent of sulphite cellulose, 40 per cent straw pulp, 4 parts size, 3 parts sulphate of alumina to 100 parts of dry stuff.

VI. 60 per cent of sulphite cellulose, 40 per cent of straw pulp, 3 parts size, and 3 parts sulphate of alumina to 100 parts dry stuff.

VII. 70 per cent of sulphite cellulose, 30 per cent of straw pulp, 3½ parts of size, and 3 parts sulphate of alumina to 100 parts dry stuff.

VIII. 100 per cent sulphite cellulose, 5 parts size, 5 parts sulphate of alumina, 2 parts stearine to 100 parts of dry stuff. The paper is good and more greasily brilliant than the others. The stearine, in No. VIII, is to be chopped into small pieces, mixed with warm water, and in this form added to the stuff in the Holland engine. According to experience, the paper made according to No. VIII, with the addition of stearine, has been found best for the different purposes.

Of the greatest importance in the manufacture of artificial parchment paper is the grinding in the Holland engine. The stuff must be ground long, to a smeary paste, and before discharging into the tub, thoroughly beaten up—after elevating the engine roller—for ¼ to ½ an hour. On the machine, it must be moderately shaken and heavily pressed. No worn-out felts must be used and the drying felts must be tightly stretched, to prevent, as far as possible, any formation of blisters in the paper; the drying must also proceed as slowly as possible, otherwise the paper will readily shrink or wrinkle. It is advisable, at the first cylinder, or better still, at the first and second, to allow, on each side of the paper web, a strip of paper 4 centimeters (about 1.6 inch) wide, to run completely around the cylinder, on which the two edges of the wet paper web can lie. This prevents too rapid a drying at the edges, and a consequent blistering of the entire paper web. The tensions in the machine must also be kept tight throughout.

A process has appeared in Europe for steel-coated iron, which can be used where the wearing qualities of steel are to be combined with the flexibility of iron, such as for car wheels and structural iron. The needed shapes are rolled in iron and then given a coating of steel which can be of any desired thickness. Great strength and a great saving in cost are claimed for the process. The patents are owned by a syndicate of which Mr. Martin Kalman, a well-known American, is the head.

MARINE PRODUCER-GAS POWER.

A COMPARISON OF PRODUCER-GAS AND STEAM EQUIPMENTS.

BY C. L. STRAUB.

So MUCH interest is exhibited both by the engineering profession and the general public in the application of producer-gas power to marine, commercial and naval service, that a brief summary of recent progress in this field appears timely.

Any innovation which makes for improvement in present practices, surely, though sometimes slowly, achieves its end. Producer-gas power, on impartial analysis, offers so many benefits to marine service that it appears strange indeed that more rapid progress has not been made in its adoption. The delay appears to be due to several causes:

The marine public, who since the days of the "Clermont" have exclusively associated the term "motive power" with "steam," have every reason for demanding exact and conclusive evidence of the superiority of gas power or any other power, before adopting it in lieu of their present methods. This evidence is only now slowly coming forth. Many who have been credited with authority by the engineering profession and others, either through ignorance or through being misinformed, have beset the way of marine gas power with numberless imaginary obstacles, ridiculous in proportion to the real difficulties, but sufficient nevertheless to instill some doubt of the possibilities of the system into the minds of the waiting public.

Only recently has such progress been made in the development of gas power for marine work, as to warrant its early adoption in commercial service. Two years ago, less than 300 horse-power in the aggregate was being developed by marine producer-gas power installations; these were experimental in nature and were of the German Capitaine type. There are now installed and accepted 23 Capitaine marine plants, aggregating 2,035 horse-power, a partial list of which follows:

a "Emil Capitaine": Launch, 60 b.h.p.; 4-cylinder single-acting, 4-cycle engine; boat 60 ft. long, 10 ft. beam, 4 ft. deep; ran an average speed of 10 miles for 10 hrs. on 412 lbs. of anthracite coal.

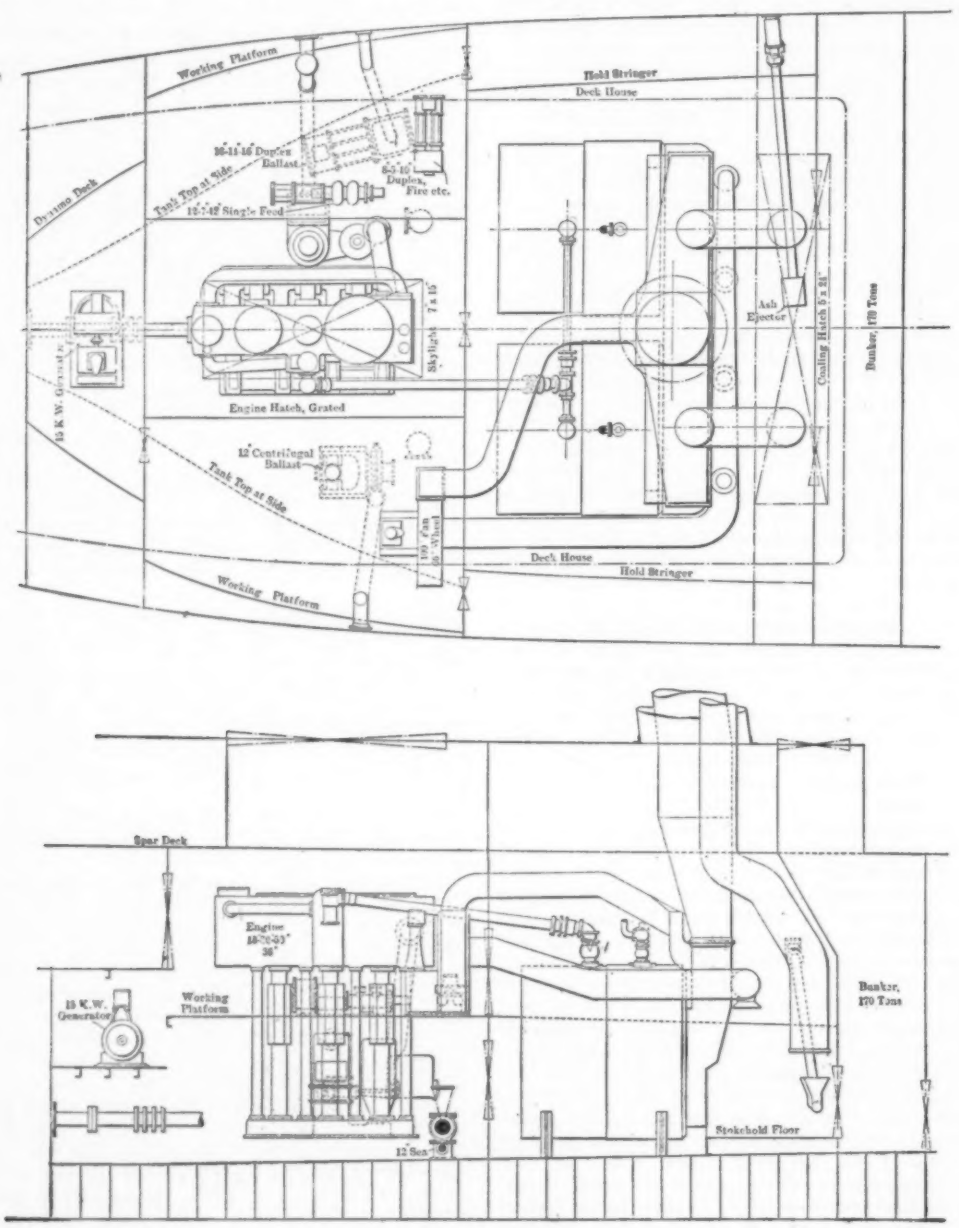


FIG. 1.—PLAN AND ELEVATION OF 1,000-HORSE-POWER STEAM POWER EQUIPMENT NOW INSTALLED IN LAKE FREIGHTER. TRIPLE-EXPANSION ENGINES; TWO SCOTCH BOILERS.

b "Rex": Sea-going Swedish boat; 102 ft. long, 22 ft. beam, carries 350 tons on 9-ft. draft; fitted with a 3-cylinder single-acting, 45-h.p. engine at 300 r.p.m.

c "Capitaine: Tow boat at Genoa; length 47 ft., beam 12 ft., draft 7 ft.; fitted with a 3-cylinder, single-acting, 4-cycle engine, 105 b.h.p. at 240 r.p.m.

d "Duchess": Canal barge; length 71 ft., beam 7 ft. 1 in.; carries 20 tons cargo on 42-in. draft; fitted with double-cylinder, single-acting, 4-cycle engine of 25 b.h.p.

e "Duesseldorf": Tug at Hamburg; fitted with a 4-cylinder, single-acting, 4-cycle engine, 60 b.h.p. at 240 r.p.m.

f "Isee": Tug, fitted with a 3-cylinder, single-acting, 4-cycle engine, 45 b.h.p., 300 r.p.m.

g "Wilhelm": Combination freight and passenger Rhine boat, fitted with a 5-cylinder, single-acting engine, 175 b.h.p. at 240 r.p.m.

h "Badenia": Rhine freight boat, fitted with a 2-cylinder, single-acting, 4-cycle engine at 30 b.h.p.

i "Katrina": Canal freight boat, fitted with a 3-cylinder, single-acting, 4-cycle engine, 45 b.h.p.

j "Marie": Canal freight boat; fitted with a 3-cylinder, single-acting, 4-cycle engine, 45 b.h.p.

k "Hoffnung": Combination freight and passenger Rhine boat, fitted with a 5-cylinder, single-acting, 4-cycle engine of 210 b.h.p.

l "Amersie": Volga freight boat, fitted with a 4-cylinder, single-acting, 4-cycle engine of 60 b.h.p.

m "No. 58": Canal freight boat, fitted with a 4-cylinder, single-acting, 4-cycle engine of 60 b.h.p.

In addition to the above there were a number of freight boats, the dimensions and names of which we were unable to obtain, but whose power plants varied in capacity from 30 to 175 horse-power each.

n H. M. S. "Rattler": An old gunboat, 165 ft. long, 29 ft. beam, originally fitted with a triple expansion engine. The gas engine is 5-cylinder, single-acting, 4 cycle. Cylinders 20 ins. diameter by 24 ins. stroke, developing 500 b.h.p. at 120 r.p.m. This engine is started by means of a mixture of gas and air which is pumped into the cylinders at a pressure of about 95 lbs. per sq. in. This complete plant was designed entirely in the Capitaine works at Duesseldorf. The total weight of the entire plant, including the donkey boiler for working the pumps and auxiliaries, is 94 tons, as compared with 150 tons in the case of the displaced steam engine. A consumption of 1,525 lbs. of coal was made for a measured distance of 45 knots on an average speed of 10½ knots per hr. The cost per mile for fuel with coal at 15s. 6d. per ton is $0.064 U. S. currency. This boat made a maximum speed of 11.3 knots per hr. against a 1½-knot current at 110 r.p.m. of the engine shaft.

All of the above plants by their design and construction are restricted to operation on anthracite coal, coke or hard-burned charcoal, and any plant so restricted by its design to one class of fuel is seriously limited in its scope of application. The development of a simple marine gas-producer for use with any class of solid fuel is a necessity, if the system is to be considered seriously by the marine profession.

The writer is fortunate in having been associated with some recent American developments both in stationary and marine gas-power plants, a brief survey of a portion of which will enable us to draw more clearly the comparison between a typical steam and a possible gas installation.

There are in commercial operation in this country to-day two distinct types of stationary power gas-producers which are suited by their design for operation on almost any class of solid fuel. They may, by their systems of operation, be qualified as up-draft and down-draft producers.

In the up-draft producer, the fuel is charged into the generator through an air-tight mechanism at the top, while air and steam, or air and products of combustion are admitted at the bottom of the fuel bed, and passing upward, leave the generator at the top in contact with the fresh fuel. Almost all of the hydro-carbons leave the generator unfixed with the hot gas, only to be condensed later in the gas coolers or scrubbers and gas mains, forming large amounts of tar, which, if not removed to a minute degree, will positively prevent the operation of the engine. The removal of this tar is troublesome and is accomplished at a loss of power and efficiency. The fuel in the upper zone of the bed in the up-draft producers cokes and cakes so seriously as to require continuous poking of the fuel bed, either mechanically or by hand. These features and others in this type of apparatus contribute to limit the rates of combustion per square foot of grate to a relatively low quantity. All things considered, therefore, this type of apparatus has not lent itself agreeably to modification for marine service.

In the down-draft type of apparatus the fuel is charged by hand through a large door at the top of the producer, which is normally in an open position, allowing the operator unrestricted inspection of the whole upper zone of the fuel bed. The hydro-carbons contained in the fuel are driven off in the upper zone, mixed with air and almost completely burned, and the burnt products, passing downward through the relatively deep bed of fuel, are decomposed and regenerated into carbon-monoxide and hydrogen gases. All of the tar and the lighter hydro-carbons are completely

fixed in this process, and no tar is found in condensation in any portion of the plant after cooling. Coking or caking of the fuel bed is not detrimental, but on the other hand, assists in keeping the fire in the open porous condition, which is desirable and necessary where high rates of combustion obtain. This feature eliminates the poking necessary in the up-draft apparatus. The gas leaves the bottom of the producer through brick-lined connections, and a portion of the sensible heat is extracted in passing through an economizer. The gas is then cooled and washed and passed through an exhausting mechanism, whence it is delivered under pressure to the engine.

This type of apparatus lends itself admirably to the high rate of fuel combustion, which for the sake of economy in space and weight is desirable in marine service. There are in actual commercial operation today a number of plants of this type having an average fuel consumption of over 40 pounds of good bituminous coal per square foot of grate per hour. These producers are sold on a rating of from 18 pounds to 20 pounds of fuel per square foot of grate per hour, which is almost 100 per cent greater than the average rating of the up-draft type of producers.

Undoubtedly a better method of measuring the ability or success of these two systems is to make note of the number and capacity of plants of each type in actual operation on engine service. A report of the Committee on Gas Engines of the National Electric Light Association, spring of 1908, showed that in gas-engine power plants, of capacities of over 300 horse-power each, there were in operation 32 plants of both types having a total capacity of 57,225 horse-power. Of these, 4 plants were of the up-draft type, having an aggregate capacity of 4,050 horse-power, and 28 plants were of the down-draft type, with an aggregate capacity of 53,175 horse-power. The latter contain the Loomis-Pettibone gas-generating apparatus, some of which have been in operation on engine service for thirteen years.

TABLE I COMPARISON OF POWER PLANTS FOR GREAT LAKES FREIGHT-CARRIER

Length over all.....306 ft. 0 in.	Displacement.....Tons gross
Beam.....45 ft. 0 in.	Cargo.....4200 net lb., 18 ft. draft
Depth.....24 ft. 0. in.	Speed, 12 statute miles per hr. on 900 i.h.p.
STEAM	GAS
ENGINE ROOM	ENGINE ROOM
3-cylinder triple-expansion, condensing, 18–30–50 by 36 in., 1050 i.h.p. at 90 to 95 r.p.m.	4-cylinder, 4-cycle, double-acting, gas engine, 24 in. diam., by 36 in. stroke 1000 b.h.p. at 95 r.p.m.
Auxiliaries steam-driven	Auxiliaries motor-driven
Length between bulkheads, 22 ft. 0 in.	Length between bulkheads, 19 ft. 6 in.
Engine room weights, including auxiliaries and piping, 182,000 lb.	Engine room weights, 105,000 lb.
BOILER ROOM	PRODUCER ROOM
2 single-ended Scotch boilers fitted with economizers, forced draught. Length each boiler, overheads 11 ft. 0 in.	Two down-draft gas producers and auxiliaries
Mean diameter, each, 11 ft. 10 in.	Diameter shell, each generator, 8 ft. 0. in.
Two 42-in. furnaces each	Inside diameter, lining generator, 6. ft. 3 in.
244 2¼-in. tubes, each	Height shell, each generator, 9 ft. 6 in.
Grate surface, each, 36.75 sq. ft.	Grate surface, each generator, 30.67 sq. ft.
Heating surface, each, 1642 sq. ft.	Producer room weights, no water, no fuel, 82,000 lb.
Boiler room weight, water in boilers, no fuel, 170,000 lb.	
Length boiler room 24 ft. 0 in.	Length producer room, includes bunkers, 15 ft. 0 in.
Length boiler room, includes bunkers, 30 ft. 0 in.	Square feet producer room, 450
	Square feet per h.p., 0.45
Square feet boiler room, including bunkers, 900	Square feet producer room with four smaller generators, 330
Square feet per h.p., 0.9	Square feet per h.p., four generators, 0.33
Bunker capacity, 340,000 lb.	Bunker capacity, 160,000 lb.
Total weight, machinery and fuel, 692,000 lb.	Total weight, machinery and fuel, 347,000 lb.
Total length of machinery space including bunkers, 52 ft. 0 in.	Total length of machinery space, 34 ft. 6 in.
	Saving in weight, 355,000 lb.
	Saving in fore-and-aft length, 17 ft. 6 in.
	Saving in cubic space 17 ft. 6 in. by 32 ft. beam by 20 ft. high, 11,200 cu.ft.

Three years have been devoted to the modification of these stationary plants for marine service. The work involved a reduction in the size and weight of the generators; complete revision of the scrubbing, gas cleansing and exhausting mechanism; elimination of all gas holders, storage receptacles, mixing chambers, etc.

The plant as modified to date has a light compact producer, which while retaining the same rate of combustion as the statonary apparatus, has materially reduced dimensions and weight of the shells, brick lining, fittings, etc. The economizer boilers which were used on stationary work have been abandoned and replaced with light air-heating economizers. The gas coolers no longer contain any coke or broken material, or wooden trays, and are built of very light, non-corrosive sheet metal, and arranged for either vertical or horizontal positions, the latter arrangement being convenient for space which would be otherwise wasted in the vessel. The cooled and partially cleansed gas is drawn through the above portion of the plant by a centrifugal gas-cleaning exhauster, driven by direct-connected motor. The gas passes directly from the exhauster under pressure, through an automatic pressure regulating valve, to the engine manifold.

That the plant is adaptable for marine service with regard to space occupied and weight, may be seen from the following conservative estimate:

Plants of from 100 to 500 horse-power each occupy from 0.4 to 0.5 square foot per horse-power, and weigh from 70 pounds to 90 pounds per horse-power, including all auxiliaries, piping, etc.; plants of from 500 horse-power to 1,000 horse-power occupy from 0.03 square foot to 0.45 square foot per horse-power, and weigh from 40 pounds to 70 pounds per horse-power, including all auxiliaries, piping, etc.

Undoubtedly the rational opportunity at the present time for marine gas power lies in commercial service, in which regard the most rapid advancement in America has been made in the freight, ore and fuel carriers of the Great Lakes.

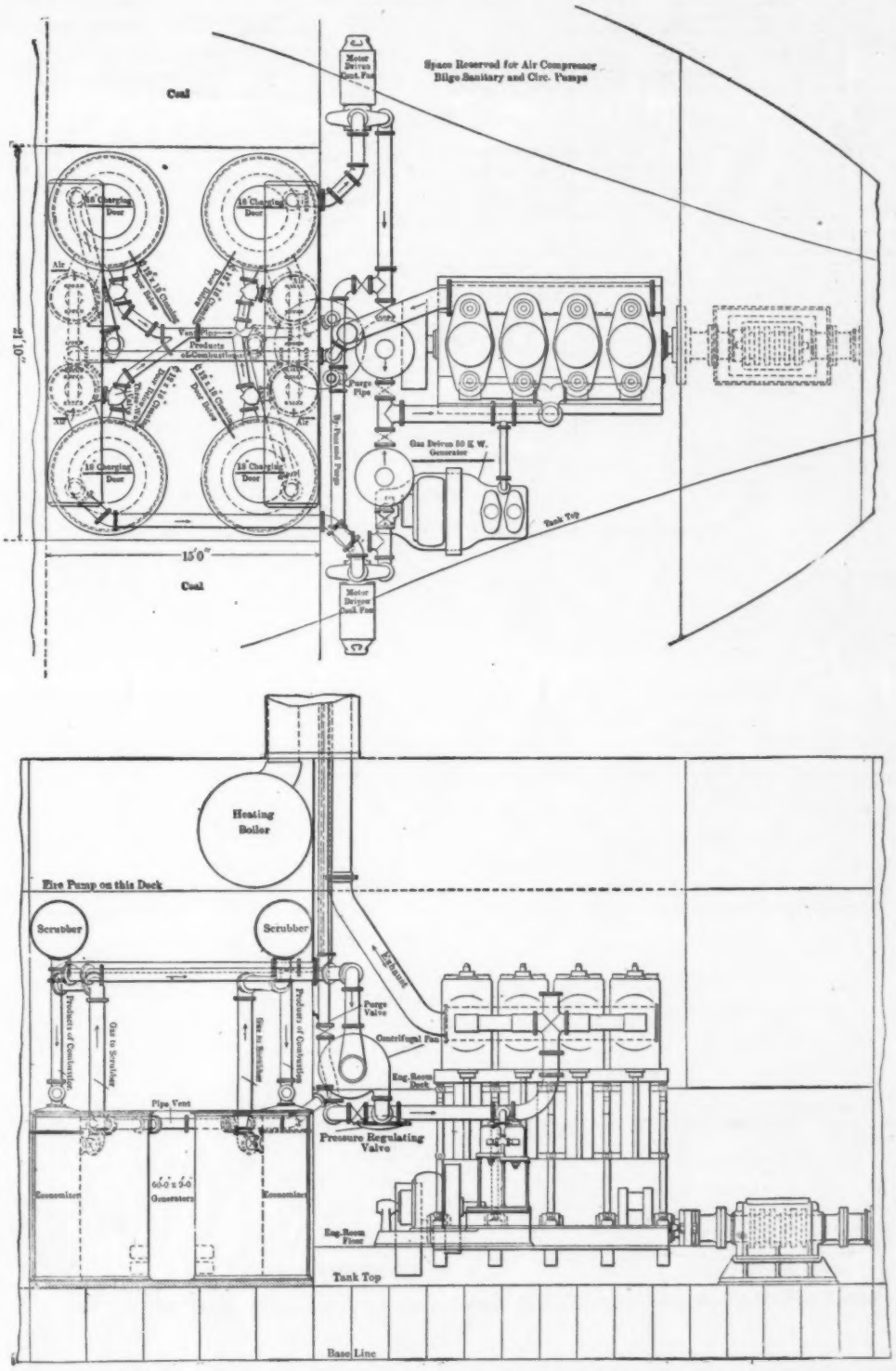


FIG. 3.—PLAN AND ELEVATION OF PROPOSED FOUR-GENERATOR MARINE PRODUCER PLANT; 1,000 HORSE-POWER.

We have therefore taken for our example a ship built from the designs of Messrs. Babcock & Penton within the last year. For the sake of clearness, the views show only the machinery space; all of the ladders, stairways and grates have been omitted from the plans, and the piping is shown only on the gas installation. The machinery installation proper is all there, however, and while the parts eliminated are merely accessory, the contrast between the two plants would be all the more striking were they included.

The boat is a modern lake freighter and represents the best standard practice in this service. She is 306 feet long over all, 45 feet beam, and 24 feet deep. Her present power equipment consists of a single-screw, triple-expansion, three-crank condensing engine, 18-30-50 by 36-inch stroke. She indicates 1,050 horse-power at 90 to 95 revolutions per minute. The engine is of the typical box-front columns and condenser back-frame type. She is fitted with direct-connected air pump and has independent steam-driven reciprocating, circulating, bilge, sanitary and feed pumps. The complete engine room weight, including piping and all auxiliaries, is, in round figures, 182,000 pounds.

The boiler room equipment consists of two single-ended Scotch boilers 11 feet 10 inches mean diameter each; 11 feet length over heads each, operating on a working pressure of 180 pounds per square inch. Each boiler is fitted with two 42-inch corrugated furnaces and has two hundred and forty-four 2¾-inch tubes. The grate surface is 36¾ square feet and the heating surface 1,642 square feet in each boiler.

The boilers are fitted with forced draft from a 66-inch steam-driven fan. The air for the draft is taken from the stoke hole and the fan is located in the engine room. The fan discharge passes through air heaters in the up-take and thence through ducts to the under side of the grates. The complete boiler-room weight, including water in the boilers, but not fuel, is 170,000 pounds. These weights are actual figures.

The coal bunker extends from the main deck to the tank top and is arranged athwartship. It has a capacity of 170 tons. The bunker doors face the stokers on the stoke hole floor. The bunker is 6 feet fore and aft at the stoke hole. The distance from the forward to after bulkhead in the boiler room is 24 feet 0 inch. The distance from the forward to the after bulkhead in the engine room is 22 feet 0 inch, making a total

over-all length for the plant, including bunkers, of 52 feet 0 inch.

The coal consumption on this vessel is from 1.08 pound to 2 pounds per indicated horse-power-hour. This coal is of approximately 13,500 B. t. u. per pound.

The problem of substitution of gas for steam, aside from the design of the construction of the gas producers or cylinders of the gas engines, has been thoroughly worked out by Messrs. Babcock & Penton, of Cleveland. The illustrations show two different arrangements of gas producers with the same engine. The proposed gas engine is a four-cylinder, double-acting, reversing type, having cylinders 24 inches bore by 36 inches stroke, delivering 1,000 brake horse-power at 100 revolutions per minute. The reversing is accomplished by means of compressed air, which is used to shift the cams from the head to the stern position. Compressed air is admitted to the cylinders by timed cams in proper cycle. The crank shaft of the engine is rigidly coupled to the tail shaft of the screw.

The illustrations show a column-framed engine. Since making this layout, the design of the engine has been modified to meet all of the present marine conditions now found in marine engine design on the Lakes. In fact, with the exception of the condenser shown on the steam drawings, the gas engine frame will be very similar to the steam engine.

For the generation of current to drive the auxiliaries, there will be installed a double-cylinder, double-acting gas engine, direct-connected to a 50-kilowatt direct-current generator. All of the pumps and auxiliaries will be motor-driven. A smaller direct-connected unit operating on oil will be used for pumping, blowing fires, or other service, when the gas plant is down. Allowing a distance of 4 feet 3 inches between the forward bulkhead in engine room and the forward side of the flywheel, which distance is one foot greater than that in the steam installation, we have an over-all distance between forward and after bulkheads in the engine room of 19 feet 6 inches.

As previously stated, two arrangements of producer room are shown. The first, the four-generator plant, consists of four 6-foot by 9-foot generators, each fitted with independent economizers. The forward pair and the after pair are connected independently to two horizontal gas scrubbers, which are shown slung under the main deck beams. The gas passes from these scrubbers to independent motor-driven centrifugal gas-cleaning fans, whence it is delivered, either through common connection to a purge or blow-off pipe which also acts as a by-pass, or through two gas pressure regulator valves to the air and gas mixing valve at the engine manifold. The 6-foot generators require only one cleaning door each. As a result a single cleaning space suffices for the four machines, allowing them to be grouped with reference to athwartship space, so as to give ample room on each side of the vessel for coal bunkers. The total space occupied by the producer plant is 21 feet 10 inches athwartship, and 15 feet between forward and after bulkheads. The producer room weight, including generators, economizers, piping, and scrubbers, complete, of the four-generator set, is 110,000 pounds. This weight is estimated, but has been carefully checked and completely covers all the mechanism. In addition to the above mechanism, there will be a heating boiler which is shown on the main deck. This boiler will serve to furnish low-pressure steam for heating the vessel and supplying hot water for washing down decks, etc. This boiler, with water, will weigh about 8,000 pounds.

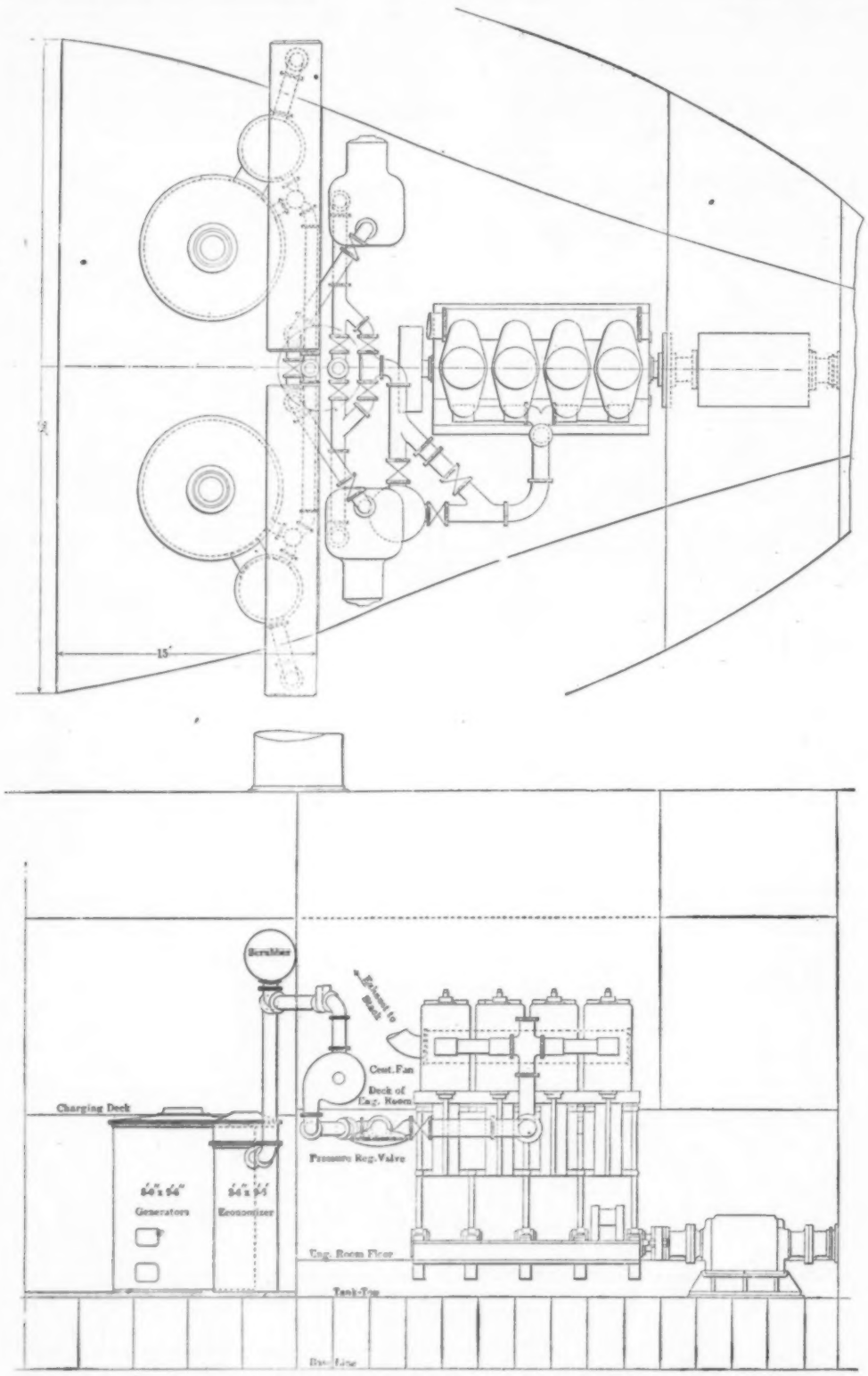


FIG. 8.—PLAN AND ELEVATION OF PROPOSED TWO-GENERATOR MARINE PRODUCER PLANT; 1,000 HORSE-POWER.

The two-generator producer plant, which will undoubtedly be the one installed, will consist of two 8 feet diameter by 9 feet 6 inches generators, connected to independent air economizers and each fitted with an independent horizontal scrubber, located athwartship under the main deck beams. The gas outlet at the scrubbers will be connected with a cross-over, so that either exhauster may operate either or both producer plants. The exhausters are installed in duplicate and are connected with common purge or blow-off and common gas outlets leading either through one pressure regulator valve, or through a by-pass direct to the air and gas mixing valves at the engine manifold.

On account of the fact that the 8-foot generators require two cleaning doors set at 120 deg. the double-generator unit plant will require the full athwartship space in the producer room. The approximate floor space occupied, therefore, will be 30 feet athwartship and 15 feet between forward and after bulkheads. The producer-room weight, including generators, economizers, piping and scrubbers complete for the two-generator set, is 82,000 pounds. This weight is estimated, but has been carefully checked and completely covers all of the mechanism. As in the case of the four-generator plant, a low-pressure boiler for heating service will be installed. In the two-generator plant, however, this boiler will be located on the producer-operating floor, so that one set of firemen may suffice for both.

The only guide we have for estimating the probable fuel consumption for this service is found in the large number of stationary producer-gas power plants now in operation. Fortunately, in marine service, the load factor will be uniformly much higher than that found in any stationary service to which gas power is applied at the present time. The builders of this apparatus are prepared to guarantee one brake-horse-power per hour on one pound of good bituminous coal, averaging 13,500 B.t.u. per pound.

Messrs. Babcock & Penton, the engineers who designed and built the steam plant, and who have spent years on the problem of the substitution of gas for steam, have suggested that the coal bunker, which will be placed above the charging deck of the producer, should have a capacity of about 80 tons of coal. These bunkers will run from the charging deck to the deck-house and will have doors opening closely adjacent to the charging doors of the generators, so that little or no coal passing on the operating deck will be required.

In making the comparison shown in the table, it is unnecessary to go into the cost of fuel, labor, hours of service, etc., as these elements vary with every class of service. In this particular proposition, it will suffice to state that the engineers who have been working on this substitution problem have conservatively figured that with the saving in fuel and the increased cargo carried, the cost of the complete plant will be saved in two years of operation.

While the gas plant here described has neither been constructed nor ordered at this writing, its forthcoming will not be long delayed, and this comparison, while somewhat premature, is made to present the possibilities of marine producer-gas power to those interested in its future.

A marine bituminous gas plant, similar in construction and operation to the one described, but of 300-horse-power capacity, has been in commercial operation driving a six-cylinder, single-acting, reversing marine gas engine for over a year. The results obtained give ample security for the statements made in this paper, and point to the early adoption of this type of prime mover for our marine commercial service.

Washing Powder.—Dissolve 10 parts of caustic potash in 80 parts of water; cold water can be used because, in dissolving, heat is generated; next dissolve in this 2½ parts of carbonate of potash, then 5 parts of borax, and finally, after cooling, 2½ parts of carbonate of ammonia. When washing, add to the first cold water, a sufficient quantity of the above preparation to make the fluid decidedly alkaline. To the first soap water add double the quantity at first and somewhat less to the second, and then rinse vigorously. To the last rinsing water but one, add some oxalic acid, dissolved in water, so that we may be certain that all the alkali is removed and will not ultimately interfere with the bluing.

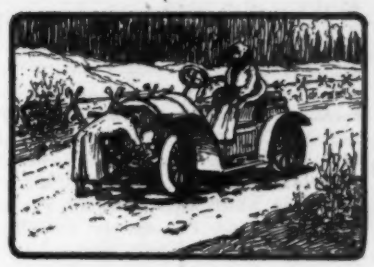
A HANDY TESTING CHART.*

WHAT TO DO WHEN THE ENGINE STOPS.

Arranged for the Scientific American by

ROGER B. WHITMAN,

Technical Director of the New York School of Automobile Engineers.



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EFFECTS OF TROUBLE.

Engine will not start. — Test ignition and carbureter. — Slow cranking or cold weather will interfere with the proper formation of the mixture. — Prime cylinders with gasoline in cold weather to obtain mixture for starting. — To increase suction in carbureter, prevent operation of air-valve.

Engine starts, but will not continue running. — Fuel does not flow freely to carbureter. Weak battery.

Engine runs well slowly, but misses when speeded up. — Worn timer. Weak battery. Faulty vibrator adjustment. Faulty carbureter adjustment. Fuel does not flow freely to carbureter.

Irregular miss. — Slipping timer. Loose half-time shaft. Sticking air-valve. Intermittent obstruction in spray nozzle. Sticking valve. Broken or weak valve-spring. Loose connection. Short circuit.

Engine will not run slowly. — Weak magneto. Faulty carbureter adjustment.

Explosions cease abruptly. — Break in ground wire, battery connections, switch lead.

Engine will not stop. — Preignition. — Glowing carbon or metal point in cylinder. Engine too hot (see Cooling trouble).

Engine noises.
- Knocking. — Too much retard of spark. Preignition. Worn bearings. Loose or cracked flywheel.
- Hissing. — Broken piston rings. Leaking air inlet pipe or gasket.
- "Popping" in carbureter. — Leaking inlet valve. Weak mixture. Excessive retard of spark.

Steady miss in one or more cylinders, (other cylinders firing normally). — Vibrator, timer, secondary circuit.

Engine does not deliver full power. — Faulty setting of valves. Tight bearings or broken balls. — Indicated by excessive heating. Back pressure. — Fouled muffler. Dragging brakes. Friction in transmission. Faulty carburetion. Weak ignition. Weak compression. Overheating.

Explosions weaken and cease. — Carbureter or fuel trouble.

IGNITION.

Jump spark, with single coil, battery secondary distributor.

Test primary circuit as described for system using coils and timer.

Secondary may short circuit from — Fouled or worn distributor. Defective insulation

IGNITION.

Jump spark, with battery, timer and coils.

To test, revolve crankshaft twice, listening for vibrators.

TEST 1. Alternate test, prime cylinders with a few drops of gasoline, close relief cocks, and crank

Explosions show ignition to be O. K.

All vibrators sound normal, primary circuits O. K. unless timer has slipped on shaft. — Vibrator should begin to operate as a piston gets to top center of compression, with spark lever retarded.

One or more vibrators sound normal, showing that battery connections, lead and ground wires, and battery are O. K.

To test coils, short circuit the timer by making contact between primary terminal of coil and ground.

- Vibrator normal, coil is O. K., look for — Interruption in timer circuit.
- Blade moves, but will not vibrate. — Punctured condenser (*a*). Short circuit at vibrator.
- Vibrator does not operate. — Faulty adjustment. — Too stiff. — Will operate only with strong battery. Excessive sparking at vibrator, and battery exhausts rapidly. — Too weak. — Feeble secondary spark; misfiring with slightly corroded contacts.
  - Contacts corroded.
  - Contacts stuck.

Vibrators do not operate. — Open switch; vibrator trouble. Trouble in battery or in primary circuit. — To test, make momentary contact from switch terminal to ground.
- Bright spark, battery lead and ground wire O. K.
- Weak or no spark. — Break in battery connections, lead or ground wire. Battery exhausted or dry cells polarized.

To test secondary, disconnect spark plug leads, support them 5/16 inch from engine ground and crank.
- Good spark, O. K.
- Weak spark. — Vibrator trouble. Plug short circuited, fouled, oily. Points too far apart—should be 1/32 inch. Short circuit in secondary. Broken condenser connection (*a*). — Shown by brilliant sparking at vibrator.
- No spark. — Short circuit in guide. Broken spring. Igniter stuck closed. Igniter insulator broken. Bus-bar or bus-bar lead. Switch or switch lead. Insulated bridge on magneto.

IGNITION.

Make and break, with low tension magneto.

Use Test 1, cranking briskly.

Explosions. — Ignition O. K. unless — Magneto is out of time and igniters incorrectly adjusted. — Should break circuit at top center of compression when spark is retarded.

No explosions.
- Short circuit. — To test operate by hand.
- Open circuit. — To test operate by hand.
- Magneto broken down. — To test magneto, disconnect magneto lead from bus-bar and hold free end in bare fingers, or

TEST 2. Hold free end against teeth of metal gear and crank briskly.

Shock or spark. — Magneto O. K.

No shock or spark. — Fouled collecting brush. Armature burned out (*a*). Fields demagnetized (*a*). — To test, unmesh gear, revolve armature by hand. If fields are O. K., armature should turn perceptibly hard twice in each revolution.

CARBURETER.

To test, hold lighted match over open relief cocks while engine is cranked briskly.

Mixture ignites. — Proving that carbureter is doing its duty.

Mixture does not ignite. Operate primer to flood float chamber.

Gasoline drips from spray nozzle.
- Mixture too rich.
  - Insufficient air. — Faulty adjustment of air valve. Clogged inlet pipe. Dust on inlet pipe screen.
  - Leaking float valve.
  - Float too heavy. — Soggy (if of cork) (*b*). Punctured (if of metal) (*c*).
  - Faulty adjustment of float.
- Mixture too poor.
  - Too much air. — Faulty adjustment of air-valve. Leaks in inlet pipe. Faulty adjustment of float
  - Water in gasoline.

No drip from spray nozzle. — Clogged spray nozzle. Clogged float valve. Clogged fuel feed. No gasoline. Empty tank. Closed supply cock.

IGNITION.

Jump spark with low tension magneto and coil (Eisemann, Remy, Splitdorf, etc.) — Proceed as in Test 1, cranking briskly.

Explosions. — Ignition O. K. unless magneto is out of time. Should be reset.

Sparks in safety spark gap. — Interruption in secondary circuit. Too wide a gap at plugs (should be from 1/64 to 1/32 inch).

No explosions.
- Primary circuit open. Primary short circuit.
- Magneto broken down. — To test magneto, disconnect primary lead to coil and proceed as in test 2.
  - Shock (or spark), magneto O. K.
  - No shock (or spark). — Interrupter short circuited, wet or oily. Field demagnetized (*a*). Condenser broken down (shown by brilliant spark at interrupter) (*a*).
- Coil broken down. — To test primary winding of coil disconnect ground wire and proceed as in second part of test 2.
  - Spark, winding O.K.
  - No spark. — Winding broken (*a*) down or short or open circuited.
- To test secondary winding of coil, disconnect spark plug leads from magneto and crank briskly, watching for sparks at safety spark gap.
  - Sparks, look for
    - Plugs short circuited. — Fouled. Insulation broken down.
    - Secondary short circuit ( ) — Fused metal bead at points. Leads short circuited.
    - Ground circuit open.
  - No sparks, winding broken down.

IGNITION.

High tension magneto (Bosch, C. & H. Lacoste, Witherbee, etc.) — Proceed as in Test 1, cranking briskly.

Explosions. — Ignition O. K. unless magneto is out of time. Should be reset.

Sparks in safety spark gap. — Break in secondary circuit. Too wide a gap at plugs (should be 1/64 to 1/32 inch)

No explosions. — To test magneto, disconnect spark plug leads from distributor and crank briskly, watching for sparks at safety spark gap.
- Sparks. — Magneto O. K. — Look for short circuits in
  - Spark plugs. — Fouled. Insulation broken down.
  - Switch lead.
  - Switch. — Bead of fused metal between points.
- No sparks.
  - Corroded interrupter contacts.
  - Interrupter stuck.
  - Armature burned out (*a*).
  - Condenser broken down (*a*).
  - Field demagnetized (*a*).

FUEL FEED SYSTEM. — To test, open drain cock at carbureter.
- Gasoline flows. — System is O. K.
- Gasoline does not flow.
  - Gravity feed. — Clogged vent hole in filling cap. Clogged piping (*d*).
  - Pressure feed.
    - Sufficient pressure in tank. — Clogged piping (*d*).
    - Insufficient pressure in tank. — Leaking tank or piping. Leaking filling cap. Stuck relief valve.

COMPRESSION.

To test, crank engine slowly, noting resistance, which should be the same in all cylinders. (Do not confuse constant mechanical resistance with intermittent resistance of compression).

Inject oil into faulty cylinder.
- Improved compression indicates — Stuck piston rings. Worn or scored piston rings. Scored cylinder walls. — Dose cylinder with kerosene and alcohol 1/2 and 1/2 to cut carbon.
- No improvement in compression indicates
  - Worn or pitted valves.
  - Leaking spark plug, igniter plate, relief cock, etc. — Test by running oil around these and cranking. — Leak indicated by bubbles.
  - Piston ring splits in line.
  - Broken piston rings. — Crank case will be abnormally warm.
  - Cracked walls or head. — Indicated by water in cylinder.
  - Sticking valves.
  - Insufficient space between valve stem and push rod.

COOLING. (Water.) — Radiator should heat evenly shortly after engine is started.
- Radiator does not heat. — Clogged circulation system. — Empty tank. Clogged piping. Defective pump. — Test by opening pet cocks.
- Radiator steams. — Failure of lubrication. — Indicated by groans from cylinders affected. — Supply should be just sufficient to produce faint whiff of blue smoke at exhaust.
  - Defect in circulation.
  - Too much running on retarded spark or on low speed.
  - Slipping fan drive.

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* It is taken for granted that the engine is capable of running properly, that the tanks are filled, and that the switch is correctly thrown.

(*a*) Return to makers for repair. (*b*) Dry in oven, and coat with shellac. (*c*) Plunge in hot water to expel gasoline and to locate leak. Repair with solder. (*d*) May be cleared with blast from foot pump.

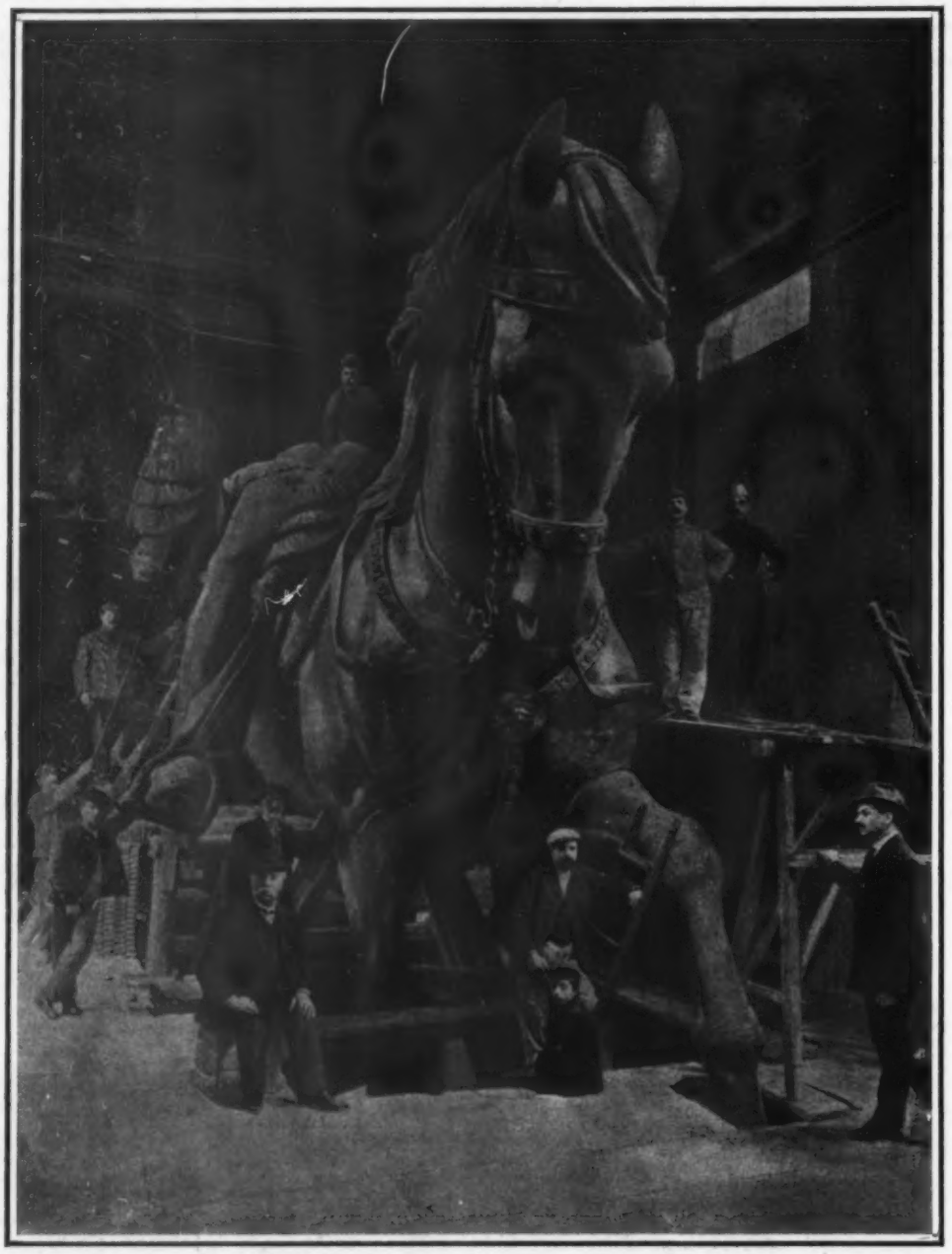
CASTING A COLOSSAL BRONZE STATUE.

THE MONUMENT TO KING VICTOR EMMANUEL II IN ROME.

THE monument to the king who gave unity and independence to Italy is beginning to loom on the summit of the Capitoline Hill in majestic grandeur. The work of Giuseppe Sacconi now emerges, in all the purity of its architectural lines, from the obstructive framework which surrounded it. The exterior of the monument is now exposed, and from the Piazza Venezia and the Corso, and even from the Piazza del Popolo, as well as from the other side, from the heights of the Esquiline and the Palatine, the superb structure can be seen standing out against the sky of Rome, towering over the city. The old enormous walls of the ancient buildings, of the Terme delle Basiliche del Colosseo, the gloomy towers of the middle ages, are vanquished; and the tidy whiteness of Signor Sacconi's attic glitters on the Capitol in the same fashion as the golden roof of the Temple of Jupiter, on the very same peak, scintillated at the rays of the sun during Rome's best days. Only one monument has been able to hold its own against the Capitoline structure in the dominion of the city—Michelangelo's Cupola. It is solitary and it stands out still a sovereign, in its colossal form, against the western sky. The fact that among all of Rome's structures the Cupola is the only one which has not been weakened, in its architectural *rapports*, by the monument to the King of Italy, ought never to be forgotten by art critics.

More than one hundred and fifty artists participated in the competition, each of whom presented his own equestrian group; but only six were called upon to make a second and final attempt, and these six were Balzico, Borghi, Cantalamessa, Civiletti, Rutelli, and Chiaradia. The latter won, and he immediately removed his studio to that Mausoleum of Augustus which is one of the many examples of the various vicissitudes which buildings, the same as men, have undergone. It was a little of everything, this mausoleum—a tomb of an emperor, a fortified castle, a Punch and Judy theater, a tavern, where the "giuoco delle boccie" was played. At one time it was used as a vineyard, and according to Monsignor Landi there were once grown there some excellent artichokes. Now that it has been transformed into a noble and beautiful concert hall, a German Kappelemeister interprets in it Beethoven's symphonies.

But to revert to the statue. Signor Chiaradia first developed his subject into another which was 14 feet high, and thereupon undertook his great task of modeling in plaster a figure 40 feet high. The sculptor worked at the monument four years, and the work was anything but finished when he succumbed to an incurable malady. It was therefore necessary to secure somebody else to finish the work; and the royal commission, with the permission of the Chiaradia family, appointed Signor Emilio Gallori successor to the deceased sculptor. Signor Gallori accepted the appointment, and in doing so, he was solely animated by a great feeling of affection toward his friend, for the task undertaken was a difficult, ungrateful, and perilous one, inasmuch as it was necessary for him to sacrifice all original ideas that emanated from his artistic temperament in order to be faithful to the artistic criteria of his deceased friend. Signor Gallori performed his task with the utmost dignity.



Illustrated London News.

A HORSE WHOSE TRAPPINGS WEIGH FOUR TONS; A COLOSSAL STEED FOR A COLOSSAL KING.

Our illustration shows the horse of the gigantic memorial to Victor Emmanuel II. of Italy. The work was begun by Chiaradia, and continued by Emilio Gallori. The bronze horse and the figure of King Victor Emmanuel II. are so large that they had to be cast in thirteen pieces. Some idea of the size of the memorial may be gained when it is said that the trappings of the horse weigh some four tons. The saber, which is over thirteen feet long, weighs nearly seven hundredweight; the pistol-holsters are higher than an ordinary man; the head of the figure, with its helmet, is 8 feet in height and weighs over two tons; the breast of the horse weighs nearly seven tons; the abdomen, nearly nine tons. Thirty persons can easily be accommodated inside the body of the horse.

CASTING A COLOSSAL BRONZE STATUE.

For the casting into bronze of the statue, the firm of G. B. Bastianelli was selected; and in 1906 the big plaster model, cut up in sections, was brought to the foundry, where it was put together again with great facility, thanks to the ingenious frame contrived by Michele Trentanove, who was of much assistance in the performance of the work, to both Chiaradia and Gallori.

For the casting in bronze the statue was divided in thirteen parts, that is, the head, the bust and legs of the king; and the head, the breast, the abdomen, the back, the tail, and the four legs of the horse.

The different items of the saddlery or trappings alone weigh something like four tons. The saber, which is over 13 feet long, weighs 770 pounds. The pistol holsters are higher than an ordinary man; they measure, in fact, 6 feet. The head of the king, which together with the helmet is 8 feet high, weighs 2 tons; the breast of the horse weighs 7 tons; and 9 tons the abdomen, for the casting of which alone 13 tons of bronze were used.

The group, which is the most colossal that has ever been cast, stands on a platform, also made of bronze, placed on the base in an absolutely original fashion. The three hoofs of the horse that rest on the platform end in the shape of a cylinder, which goes through the base (provided also with another cylinder) for more than 20 inches, at the end of which there is a very strong disk, to which they are attached by means of a screw system, which starts from the upper part of the horse's leg. Moreover, the base is traversed, through its length and breadth, by a series of small arches, which lend to it an enormous amount of strength, while retaining for it a comparative degree of lightness.

The interior of the horse has, as can be seen from our photograph, the appearance of a long grotto; thirty-odd persons can sit very conveniently at banquet in it. This horse recalls to our mind the huge animal which, constructed under the direction of Pallas, was introduced into the city of Troy, filled with arms and men, so that the fatal machine of war could pass. Says Aeneas:

"Dividimus muros et moenia pandimus urbis."

—Translated from L'Illustrazione Italiana.

RADIOACTIVITY IN RELATION TO GEOLOGY AND OTHER SCIENCES.

By M. P. BESSON.

THE discovery of radium and the phenomena associated therewith have revealed to us new truths of so fundamental a character, that there is hardly any branch of science which has not in some way profited by the new knowledge.

First of all, perhaps, our thoughts naturally turn to some questions which arise in connection with the occurrence of radium and radioactive manifestations in nature. We are thus led to the consideration of these phenomena in their relation to mineralogy and geology, and to the closely connected subject of the radioactivity of springs and of the atmosphere.

First then, as regards radioactive minerals, a study of these has shown that their activity is proportional to the uranium content. Of a score or more examined, all without exception showed this relation very clearly. Such slight divergences as occurred between different specimens are readily accounted for by errors of analysis. This fact was established by Boltwood of Yale University, and was adduced by him in evidence of the truth of a hypothesis suggested by Rutherford, namely, that radium is a transformation product of uranium. Since the transformation takes place at a perfectly definite rate, while radium itself undergoes further disintegration, also at a definite rate, the proportionality of the radium present (measured by the radioactivity) to the uranium is thus accounted for.

As regards the nature of these successive transformations of uranium into radium and further products, it is best exhibited by such a table as the following, which is essentially a synopsis of the results gained by Ruth-

erford, Soddy, and Debierne. The first column shows the successive products of transformation in their proper order. In the second column is given the "mean length of life," which may be taken as a measure of the rate of disintegration of the corresponding product:

Substance.	Atomic Weight.	Mean Length of Life.
Uranium	240	10^9 years
Uranium X	234	31.6 days
Unknown body	234	31.6 days
Radium	226.5	2,000-4,000 years
Emanation	222.5	15.8 days
Radium A	218.5	4.3 minutes
Radium B	214.5	37.4 minutes
Radium C	214.5	27.4 minutes
Radium D	210.5	57.5 years
Radium E	210.5	8.6 days
Radium F (Polonium)	210.5	201 days
Unknown (lead?)	206.5	?

A remarkable fact brought out by this table is that in nearly all cases the difference between the atomic weights of successive products is 4. Now the "emanation," the fifth product on the list, is a gas which has been shown to produce helium in its disintegration. The atomic weight of helium is 4. It appears therefore that the successive atoms are derived one from the other by the elimination of a helium atom.

An examination of various rocks has established the following facts:

1. All igneous rocks are radioactive; sedimentary rocks are more or less so, according to the materials derived from igneous rocks which they contain.
2. Iron contains little radium, meteoric iron none.
3. Lavas, volcanic gases, and other volcanic products contain no radium.

Now radium in its disintegration gives out heat. Thus one gramme evolves 100 calories per hour. The question has therefore been raised, whether the radium content of the earth is sufficient to account for the internal heat, and for the heat lost by the earth by conduction and radiation. A simple calculation shows that if the distribution of radium were the same in the earth's interior as it is at the surface, the heat produced would exceed that which is given off by the earth. This means that the temperature of the earth would increase continually—a conclusion which is hardly in keeping with facts. But we noted above that volcanic matter contains no radium. There is therefore good evidence to show that it is only the earth's crust in which radium is present. If we make this assumption, and further suppose that radium is the only source of heat within the earth, we find that, to account for the total heat lost, the earth's crust must be about thirty miles thick. Now this is just the thickness which has been calculated independently by Milnes from the velocity of propagation of earthquakes.

Rutherford has shown that the heat radiated by the sun can be accounted for on the supposition that the sun contains 1 gramme of radium per cubic meter. We may perhaps regard the sun as a system in which radioactive processes are proceeding with full force, the earth as one in which they are declining, and the moon as a system whose radioactive life is extinct.

Mention was made above of the radioactivity of the atmosphere. The presence of a radioactive emanation in the air was observed by Elster and Geitel. They placed a conducting wire 10 meters in length under a negative potential of 2,000 volts. The surface of the wire was found to become radioactive. The radioactive agent could be collected by wiping it off the surface of the wire with tissue paper or cotton wool. The radioactivity of the air can be measured by filtering a known volume of air through cotton wool, and then determining the radioactivity of the latter in the usual way. We may briefly recall here that this consists in observing the influence of the radioactive material, when placed in the neighborhood of the leaves of a charged electroscope, upon the rate of discharge of the instrument.

Rain and newly-fallen snow are radioactive. The data which have been collected regarding the radioactivity of the air at different times of the day or year and in different places are somewhat confusing, and it seems difficult to disentangle any order or law from the facts observed. There seems little doubt that the radioactivity of the air in certain cases has its origin in the soil. On the other hand, it seems equally certain that solar protuberances and sun spots have a marked influence upon the amount of emanation present in the air, just as they are known to materially affect all other manifestations of atmospheric electricity.

In the science of chemistry again an entirely new horizon has been created by the discovery of the radioactive phenomena. Radium emanation is the most intensely energetic chemical agent known. It was stated above that one gramme of radium evolves 100 calories per hour. According to Rutherford 75 out of these 100 are to be attributed to the emanation, which undergoes further disintegration, emitting the so-called α rays. Thus 1 cubic centimeter of emanation emits in the course of its entire "life" a quantity of heat of the order of 7×10^6 calories. Compare with this the 3 calories evolved in the explosion of 1 cubic centimeter of a mixture of hydrogen and oxygen.

Of the highest significance are the facts brought to light by the study of radioactive phenomena with regard to the transmutation of elements which seems to accompany these manifestations. But these investigations are still in their initial stage and there are many doubtful points to be cleared up.

THE CAST OF THE BUST.

In conclusion, let us point to the wonderful perspective opened up, should it at some future time become possible to cause the immediate and rapid disintegration of matter. Thus one gramme of radium would furnish an amount of heat equal to that derived from 325 tons of coal! If then we are faced with problems of the exhaustion of our natural resources, of the depletion of our coal mines, there is no means of gaging the possibilities which the future may hold in store, and which may surpass the most extreme limits of our needs.—Abstracted from Le Bulletin des Ingenieurs Civils de France.

WEEKLY WEATHER FORECASTS.

By PROF. E. B. GARRIOTT.

WEEKLY weather forecasts are based upon a consideration of atmospheric pressure over the oceans and continents of the Northern Hemisphere. Details of the calculations, that rest largely upon knowledge acquired by study and experience, can not, of course, be readily furnished. In a general way, however, it may be stated that the dependence of local weather changes upon world-wide atmospheric conditions has long been recognized, and careful studies of the relation and association of the great oceanic and continental barometric areas with marked types of weather have been made. In previous years studies of this character have necessarily been made with reports received by mail. During the past year daily telegraphic reports from selected stations throughout the Northern Hemisphere have permitted an application of the knowledge derived from these studies.

In the balancing of air masses over the Northern Hemisphere is found a cause of normal and abnormal weather in various portions of the hemisphere. In winter the greater masses, which are represented by areas of high barometric pressure, occupy the continents, and in summer the oceans are the seats of the so-called permanent areas of high barometer. In the shifting of the areas is produced what may be termed an annual ebb and flow of atmospheric tides; the air currents, or prevailing winds that attend the tides, are important factors in climatic changes and conditions. Marked departures from a normal distribution of air pressure result in decided departures from seasonal weather. In the relation of normal and abnormal pressure distribution to seasonable and unseasonable weather is found the problem of forecasting for periods of one to two weeks in advance. Generally speaking the distribution of pressure that is peculiar to a certain season will produce in a modified degree the weather of that season irrespective of the time of year.

The character of the barometric distribution over the Pacific Ocean and the continent of Asia indicates the development or approach of storms and high-pressure areas that will appear on the western coasts of the North American Continent; and barometric conditions over the Atlantic Ocean and Europe indicate the direction and speed of the movements over the American Continent. Marked departures in the Asiatic area indicate the general character of the weather of the United States for a period of about two weeks in advance; and Pacific pressure conditions and changes furnish a key to weather changes that will occur on the Pacific coast of the United States three or four days in advance, and indicate the character of those that will occur over the eastern portion of the United States six to seven days in advance. The strength or magnitude of the storms, cold and warm waves, and other meteorological phenomena bear a relation to the departures from the normal pressure that appear over the oceanic and continental areas referred to.

The next advance in the forecast period will be achieved when the cause of unseasonable and unusual barometric pressures over the oceans and continents is known. If, as has been suggested, such abnormalities are due to variations in the solar radiations, the fact may be discovered when appliances for measuring the variations, if any exist, are perfected. In the meantime observed conditions and changes in world-wide pressures must form a base of operation, and facts, not theories, must be employed by the forecaster.—Monthly Weather Review.

Chloroform is now produced by electrolysis of a solution of 50 parts of crystallized calcium chloride ($CaCl_2$, $6H_2O$) in 100 parts of water, to which 0.6 part of alcohol is added. The electromotive force used is 3 or 4 volts, and the current density is ¼ ampere per square inch. The solution is kept at a temperature between 136 deg. and 145 deg. F. The chloroform distills over and is condensed and collected.

A PARTY OF MEN SEATED IN THE INTERIOR OF THE HORSE.

CASTING A COLOSSAL BRONZE STATUE.

NEW PHOTOMETRIC UNITS.

AN IMPORTANT INTERNATIONAL AGREEMENT.

WE have received from the National Physical Laboratory of Great Britain the following announcement relating to the establishment of an "international candle" photometric unit:

In order to determine as accurately as possible the relations between the photometric units of America, France, Germany, and Great Britain, comparisons have been made at different times during the past few years between the unit of light maintained at the Bureau of Standards, Washington; at the Laboratoire Central d'Electricité, Paris; at the Physikalisch-Technische Reichsanstalt, Berlin, and at the National Physical Laboratory, London.

The unit of light at the Bureau of Standards has been maintained through the medium of a series of incandescent electric lamps, the values of which were originally intended to be in agreement with the British unit, being made 100/88 times the Hefner unit.

The unit of light at the Laboratoire Central is the bougie decimale, which is the twentieth part of the standard defined by the International Conference on Units of 1884, and which is taken, in accordance with the experiments of Violle, as 0.104 of the Carcel lamp.

The unit of light at the Physikalisch-Technische Reichsanstalt is that given by the Hefner lamp burning at normal barometric pressure (76 centimeters) in an atmosphere containing 8.8 liters of water vapor per cubic meter.

The unit of light at the National Physical Laboratory is that given by the 10-candle-power Harcourt pentane lamp burning at normal barometric pressure (76 centimeters) in an atmosphere containing 8 liters of water vapor per cubic meter.

In addition to the direct intercomparison of flame standards carried out recently by the national laboratories in Europe, one comparison was made in 1906 and two in 1908 between the American and European units by means of carefully seasoned carbon-filament electric standards, and as a result of all the comparisons the following relationships are established between the above units:

The pentane unit has the same value within the errors of experiment as the bougie decimale. It is 1.6 per cent less than the standard candle of the United States of America, and 11 per cent greater than the Hefner unit.

In order to come into agreement with Great Britain and France, the Bureau of Standards of America proposed to reduce its standard candle by 1.6 per cent provided that France and Great Britain would unite with America in maintaining the common value constant, and with the approval of other countries would call it the international candle. The National Physical Laboratory, London, and the Laboratoire Central d'Electricité, Paris, have agreed to adopt this proposal in respect to the photometric standardization which they undertake, and the date agreed upon for the adoption of the common unit and the change of unit in America was April 1st, 1909. The following simple relations will therefore hold after that date:

Proposed new unit = 1 pentane candle = 1 bougie decimale = 1 American candle = 1.11 Hefner unit = 0.104 Carcel unit. Therefore, 1 Hefner unit = 0.90 of the proposed new unit.

The pentane and other photometric standards in use in America will hereafter be standardized by the Bureau of Standards in terms of the new unit. This, within the limits of experimental error, will bring the photometric units for both gas and electric industries in America and Great Britain and for the electrical industry in France to a single value, and the Hefner unit will be in the simple ratio of 9/10 to this international unit.

The proposal to call the common unit of light to be maintained jointly by the national standardizing laboratories of America, France and Great Britain the "International candle" has been submitted to the International Electrotechnical Commission, and through it to all the countries of the world which are represented on that commission.

The above agreement has received the approval of the British Gas Referees and the standards of the National Physical Laboratory are being maintained in accordance with it.

After the above matter was in type the Bureau of Standards issued a circular dated May 20th, in which similar announcement is made of the agreement relative to the unit of light. In addition, the circular of the bureau gives the following account of the history of the new unit and the bearing of its adoption on the electrical and gas interests:

The above announcement marks an important step forward in the history of photometric measurements. For many years the British Parliamentary candle was the unit recognized in this country, but the lack of precision in practical photometry did not permit its value to be very accurately expressed or reproduced. In recent years the gas industry has employed the 1-candle-power sperm candle, the 10-candle-power Harcourt pentane lamp, the Hefner lamp, and various secondary standards, while the electrical industry has employed incandescent electric lamps either certified by the Bureau of Standards or rated in terms of standards that are consistent with those of the bureau. The unit of the bureau has been maintained very constant, as shown by frequent comparisons with the standards of France, Germany, and Great Britain, but different appreciably from the British unit and hence from the unit employed by most of the gas companies in America.

The Bureau of Standards took the initiative several years ago in bringing about international uniformity in the unit of light by sending its representatives abroad with copies of its standards to determine more accurately the relative values of the units of the several European countries and to urge the adoption of an international unit. In this country the American Institute of Electrical Engineers, the American Gas Institute, and the Illuminating Engineering Society have acted together in support of the movement, and have voted in advance to recognize the new unit of candle-power.

In England the National Physical Laboratory has secured the indorsement of the London Gas Referees and the Institution of Gas Engineers.

The union of the three national standardizing institutions of America, France, and Great Britain in maintaining a common unit of candle-power, and the co-operation of the German Reichsanstalt in redetermining, from time to time, the ratio of the Hefner unit to the common international candle, assures the highest attainable constancy for the new unit of light.

Unfortunately there is no primary photometric standard that is sufficiently constant and reproducible to be generally accepted as an international standard. France, Germany, and Great Britain each have their own primary flame standard, and a great deal of effort has been expended in attempting to determine accurately the relations between them. Until the flame standards themselves are better understood, however, and the atmospheric and other conditions more perfectly controlled, the unit of light cannot be preserved as accurately by primary-flame standards as by incandescent electric secondary standards. The latter, when well made, properly seasoned and carefully measured, permit comparisons to be made (using the means of many settings on several lamps) with excellent precision, the lamps themselves being constant enough and the precision of measurement high enough to fix the final values to about one-tenth or two-tenths of 1 per cent. There is good reason to believe that in this way the international unit of light can be preserved so nearly constant that any inevitable drift occurring one way or the other would be too small to detect with certainty by any of our present flame standards in many years. The Bureau of Standards will continue to standardize flame standards by the electric standards and will also carefully investigate the flame standards. Similar tests and investigations will also be made in Europe, and if any appreciable drift does occur it will sooner or later be detected.

Careful distinction should be made in this connection between a unit and a standard. An international unit maintained by the co-operative effort of several national standardizing institutions, and checked from time to time by means of all the best primary standards in use, is more likely to be maintained constant than if it were defined to be represented by any single primary standard, unless such a primary standard were reproducible to a very high degree of precision. Such a unit can be continued permanent even though all present primary standards are ultimately superseded by better ones. The Hefner lamp as a convenient flame standard will not be displaced in America or any other country which adopts the international candle as its unit of light. Uniformity among different countries and continuity of value are prime necessities with respect to the unit. But the particular standard by which the unit is realized in practice is largely a matter of convenience and circumstance. In photometry of electric lamps electric standards are most suitable. In gas photometry one form of flame standard or another will be employed according to circumstances. It is not expected that all countries of the world will at once adopt the proposed international candle as their unit of light. Those countries which already have the Hefner unit in general use may prefer to continue it. But if all countries which have a unit differing appreciably from the Hefner shall adopt the international candle as their unit, there will then be only two units in use throughout the world, and they will have the simple ratio 9 : 10. This would result in a distinct gain both in the practice of photometry and in definitions and nomenclature.

The effect of this change of 1.6 per cent in the unit of the bureau, which is in general use for electric lighting throughout the country, is to raise the candle-power rating and decrease slightly the watts-per-candle of electric lamps. A 16-candle-power lamp will give 16.26 candles in the new unit, or a 16-candle-power carbon-filament lamp burning at 110 volts will give 16 candles on the new basis at 109.69 volts. The change, though small, is important in the photometry and rating of lamps.

The new unit of candle-power being in agreement with the present English unit as represented by a 10-candle-power standard pentane lamp, there will be no change in the unit of light now employed by those gas companies which use pentane lamps, provided they are in agreement with the English standard. But as pentane lamps may differ slightly from one another, even when burned under the same conditions, it is desirable for the sake of greater uniformity to have them standardized in terms of the standard candle of the bureau. These variations, amounting to from 1 to 5 per cent, are generally in the same direction; that is, the lamps if not correct usually give less than 10 international candles under standard conditions when burning in a pure atmosphere at a normal barometric pressure of 76 centimeters of mercury, and an atmospheric humidity of 8 liters of water vapor per cubic meter. In anticipation of this change some of the largest gas companies in the United States have already had their pentane and Hefner standard lamps standardized by the bureau in terms of the new unit.

Gas standards will hereafter be certified in terms of the international candle. Electric standards will be certified in terms of the old unit until July 1st, 1909, unless otherwise requested. On July 1st the new unit will be adopted by the Bureau of Standards in the certification of electric standards, and it is hoped that manufacturers of electric lamps will adopt the new unit as soon thereafter as possible.

The bureau recommends that all gas and electric companies, all photometric laboratories, and all the manufacturers of electric lamps in the United States adopt the new unit of candle-power, if possible, not later than January 1, 1910. Further information with regard to change of photometric unit or to the testing of gas and electric standards will be given by the bureau on request.

We understand that several countries have joined the United States, England, and France in adhesion to the new unit, and that favorable action from a number of others is expected in the near future.—Electrical World.

PERMANENT MAGNETS OF NEARLY PURE COPPER.

IRON, nickel, and cobalt show well-marked magnetic properties, but most of the other elements, although they may acquire such properties under the influence of a very strong magnetic field, retain only very small traces of magnetism after they have been removed from that field. Heusler has recently discovered that certain alloys of non-magnetic metals retain considerable permanent magnetism. Still more recently, Gray and Ross have been investigating the possibility of increasing by special treatment the feeble magnetic properties of copper, a metal which is peculiarly interesting in this connection because it is so largely employed in electro-magnetic apparatus and also because it is one of the constituents of Heusler's magnetic alloys.

Specimens of copper were subjected to the influence of the great electromagnet of the University of Glasgow. This magnet is made of cast steel, having a magnetic permeability almost identical with that of wrought iron. It is rectangular in form, about 40 inches long, and 16 inches wide. Despite the great distance between the conical pole pieces a field of much more than 3,000 C. G. S. units was produced by a current of 15 amperes.

A Dewar flask, containing liquid air in which a piece of copper was immersed, was placed between the pole pieces. The copper, which was thus cooled below —330 deg. F., showed feeble traces of permanent magnetism, but another specimen, which had previously been heated to a bright red heat, exhibited no magnetism whatever.

When the heated copper was quenched in cold water a considerable deflection of the magnetometer was ob-

served. The effect was much greater in sheets of electrolytic copper less than 1/80 inch thick than in massive copper. The permanent magnetism of such sheets, which contained less than 4/100 per cent of iron, was about 14 C. G. S. units, more than five times as much as could be accounted for by the small quantity of iron in the copper.

The permanent magnetism of heated and quenched copper is very little affected by slight shocks. It is greatly diminished by energetic hammering but is restored, almost to the former degree, by a second magnetization. It is also diminished to some extent by heating.

A bar of very pure copper, produced by electrolysis and weighing one ounce, failed to show the slightest trace of permanent magnetism.

Although the permanent magnetism of the sheets of electrolytic copper was apparently due to the presence of impurities, it could not be accounted for by the trace of iron, regarded as free iron. Possibly the iron combined with copper to form a magnetic alloy. This view is supported by the fact that the electrical properties of copper are also greatly affected by traces of impurities.

HOW THE EARTH LOOKS FROM THE MOON.

STUDIES OF EARTHLIGHT.

BY WILHELM KREBS.

To A human observer placed on the moon, the earth would present a very beautiful appearance. The lines of the picture would not be greatly influenced by the position of the moon, which is never more than 28½ deg. distant from the plane of the earth's equator. Hence the average view would be well represented by an equatorial orthogonal projection of the earth's surface, in which the polar regions would be greatly compressed and would show little detail. The character of the picture would be determined as much by the distribution of clouds as by the geographical features of the earth's surface. The effect produced by clouds on the colors of a landscape has only recently been appreciated. The peculiar charm of views seen from balloons is largely due to intervening clouds.

Some idea of the appearance which the earth would present to an observer on the moon may be gained from a consideration of the peculiar grayish tint of that part of the visible hemisphere of the moon that is not in direct sunlight. This effect is produced by sunlight reflected by the earth to the moon, as was divined by Leonardo da Vinci, four hundred years ago. The laws which govern the intensity of this earth light were studied and formulated by Galileo in the 17th century, and more thoroughly by Schroeter in the 19th. The empirical rules thus laid down contradict each other and are open to other objections, but they served as the basis of a good working theory, which was adopted by Lambert and subsequently by Schroeter himself. According to this theory the earth light which illuminates the moon should be more intense when it is reflected by the land surface of the eastern hemisphere than at times when the Atlantic Ocean is turned toward the moon.

But Schroeter's empirical law is susceptible of a very different interpretation. For example, Schroeter found the earth light brighter on autumn mornings than on evenings in spring. Now, in the temperate zone, regions covered by vegetation are usually overspread by white clouds far more thickly on autumn mornings than on spring evenings. I have been led to attribute the brightness of the earth light to the white covering of extensive surfaces, because I found the earth light remarkably bright and white at new moon in February, 1901, when the interior of the European continent was covered with an unusually heavy mantle of snow and a correspondingly heavy pall of clouds overhung the European coasts. Similar phenomena were observed in March, 1908, when the northern parts of America and Asia, as well as Europe, were very deeply and extensively covered with snow. In the months that followed all three continents were deluged with floods and covered with unusually dense clouds.

In 1893 I published a synopsis of the results of observation published by Woeikof in 1887, showing the uniformly great cloudiness of the polar and equatorial regions, and the less dense cloudiness of the temperate zones. In 1896, Arrhenius obtained substantially the same results from the material published by Teisserenc de Bort in 1884. I found the southern hemisphere 13 per cent, and Arrhenius found it 10 per cent more cloudy than the northern.

Hence the north temperate zone is the region most favorable to variations in cloudiness. If my theory of the preponderating influence of variations in cloudiness and snowfall upon the intensity of the earth light is correct, the various pale tints which are occasionally seen in the earth light can be explained by reflection of sunlight from the exposed land and water surfaces of the earth.

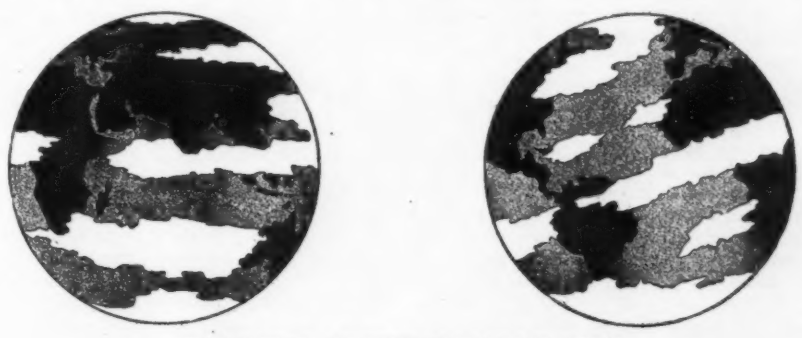
Three of these tints, blue, green, and yellow (the only ones observed until last year) can be ascribed, respectively, to reflection from oceans, foliage, and deserts. In the spring and early summer of 1908 I detected a fourth tint, which to me appeared reddish, but to other observers violet or lilac. During the same period cirrus clouds were unusually abundant, and the sunset glow was often very red and persistent. A similar coincidence was observed in Italy in January, 1909.

The explanation is easy. The reddish tone of the earth light was due to light reflected to the moon by the red zone of twilight which encircled the "full earth."

If these variations of intensity and tint are due to variations in cloudiness and snowfall on the earth and to variations in the earth's surface, and if we are able to detect them in the feeble earth light sent back to us by the very rough surface of the moon, 240,000 miles away, it is evident that, to an observer on the moon, the earth would appear as an object of great and ever-varied beauty, inlaid with many colors, which incessantly change in brightness and tint as its different parts successively come into view and as it is more or less covered with snow and clouds, and invested with the red glow of twilight.—Kosmos.

THE MOUNT WILSON 60-INCH REFLECTOR.

On December 13th, 1908, the first visual tests of the performance of the great 60-inch reflector were made on stars at the Mount Wilson Solar Observatory in California, and on the 19th photographic records were obtained, from which it was at once evident that the new instrument was so nearly perfect as to satisfy all the expectations of its designer and constructor, Mr. G. W. Ritchey, optician of the observatory. The telescope is designed to be employed in four ways—(1) as a Newtonian, with a double slide plate carrier for direct photography and spectroscopic work; for this the focal length will be 299 inches (7.6 meters); (2) as a Cassegrainian, for direct photography, having an equivalent focal length of 100 feet (30.5 meters), the enlarged image being formed at the north side of the tube near its lower end; (3) as a Cassegrainian for spectroscopic work on a large scale, focal length 80 feet (24.4 meters); (4) as a Cassegrainian-Coudé for spectroscopic work with a large stationary spectroscope at the bottom of the hollow polar axis in a constant temperature chamber; focal length about 150 feet (45.5 meters).



THE EARTH AS SEEN FROM THE MOON.

A specially interesting feature of the manufacture of this large mirror is that the grinding and polishing tools were only about one-quarter the area of the large mirror, the final polishing being completed with a 90-deg. sector-shaped tool. In the early stages of paraboloizing the tests were made at the center of curvature, but the final tests were made at the principal focus.

The mounting is very massive, but the friction of the polar axis has been relieved to a considerable extent by an ingeniously adapted mercury float. The greater part of the polar axis and its supports are below the floor level. At the head of the polar axis is a flange 4½ feet diameter and 6 inches thick, to the lower side of which is bolted the float, which is a very rigid, hollow cylinder of steel boiler plate 10 feet diameter and 2 feet deep. This dips in a cast-iron trough, which is machined to nearly fit the float, leaving a space of only ⅛ inch all round; this space is filled with 650 pounds of mercury, the immersed part of the float giving a displacement of about 50 cubic feet, thus carrying 21½ tons of the moving weight of the telescope. In this way about 95 per cent of the weight on the bearings is taken up, and the mounting is so designed that the center of weight is vertically above the center of flotation. The gear wheel on the polar axis is 10 feet diameter, with 1,080 teeth. To the upper side of the flange is bolted the massive fork between the arms of which the telescope tube swings in declination on nickel steel trunnions.

The telescope is provided with electric quick and slow motions, in both right ascension and declination, and the wiring is so arranged that these can be operated from several convenient points. The octagonal skeleton tube is built up of eight conical steel tubes about 15 feet long, with three rigid rings connecting them and the diagonal bracing. To carry the various secondary mirrors for adapting the instrument to any of the four types mentioned, four cages are provided which are fitted to the upper end of the skeleton tube. The double slide plate carrier is planned to take either 5 x 7-inch or 6½ x 8½-inch photographic plates.

A most elaborate system has been adopted for the building and dome, which is made to be quite air-tight. The outer skin has double sheet steel walls 2 feet apart, and all windows, doors, and the slit in the dome close against rubber packing. The dome is 58 feet diameter, with an observing slit 16 feet wide, which is operated by a 6-horse-power electric motor. The observing platform is suspended from the dome near the shutter opening, and is so arranged that all its motions are controlled by push buttons, either from the platform itself or from the floor. An adjustable wind screen 17 feet wide and 35 feet long can be adapted to protect the telescope from wind or lights in the neighboring valley.

To preserve the mirror as much as possible from change in temperature the building will be hermetically closed each morning, inclosing about 120,000 cubic feet of cool air, and it is hoped that this will remain cool during the day. After sunset the ventilating doors will be opened, and after a free circulation has been maintained, all will be ready for the commencement of observations.

Coming now to the actual performance of this mammoth reflector, it has been found that the figure of the 50-inch is notably superior to that of the 24-inch made by Mr. Ritchey at the Yerkes Observatory, which has provided such glorious views of the Andromeda nebula and other celestial objects. Combined with this we note that the mounting is so perfect that the star in the guiding eyepiece remains perfectly bisected on the spider lines for several minutes at a time, without perceptible tremor, and it is possible to see the star image so sharp and small that the diffraction pattern is as perfect as ever seen with the 24-inch.

From what we know of Mr. Ritchey's previous work we can now confidently anticipate such additions to our knowledge of the celestial bodies as will be worthy of the enormous expenditure and skill which have been necessary for the installation of so mighty an instrument of astronomical research.—Knowledge and Scientific News.

REVOLVING BALLOON SHEDS.

A NEW TYPE OF AIRSHIP SHED THAT HAS SEVERAL ADVANTAGES.

A VITALLY important question in connection with aeronautics is the building of proper sheds for the protection of airships—particularly in the case of those of the rigid frame type.

Among various proposals for this purpose is that of the construction of a sort of gigantic drydock like that used for ocean steamers. But as this would have to be roofed for the necessary protection of the balloon against sun, rain, and snow, it offers no advantage beyond that of an ordinary covered shed.

The most practical, so far, is that of Count Zeppelin on Lake Constance, which is so anchored as to be turned in any direction, according to the quarter of the wind, thus avoiding the danger of injury to the balloon when about to enter or leave the shed.

This is undeniably an arrangement of great practical value, and it has been proposed to attain it at inland situations by means of mounting the shed in a huge turntable, moved mechanically. But the expense both of construction and operation would be forbiddingly formidable.

The following scheme, invented by Engineer Gustav Unger of Kamen, evades this difficulty, and solves the problem very neatly by erecting the shed in a circular pontoon, floating on the surface of the water in an artificial basin.

The accompanying diagrams show different views of such a shed, meant for the accommodation of two dirigible balloons of moderate size.

Fig. 1 shows a side view of the shed, with section through the ground.

Fig. 3 shows the ground plan, and Figs. 2 and 4 show different sections.

On a circular pontoon *d* rests a shed constructed of iron and extending equally on either side. The diameter of the pontoon corresponds to the width of the shed. The ends of the shed projecting beyond the pontoon are supported upon a circular track by means of rollers, so that, in case of unequal weighting of the shed, the latter would take up a part of the pressure, and at the same time prevent it from tilting out of its horizontal position.

By the regulation of the water level in the basin, the pressure on the rollers is regulated to a nicety, so that comparatively little power is needed to revolve the shed.

In the wall of the basin are fixed guiding rollers, *r*, which prevent friction of the pontoon against it.

By means of a turning and guiding axis fixed exactly in the middle of the pontoon and basin, an exactly central revolution of the shed is attained, which object is also assisted by the above-mentioned guiding pulleys. Because of the latter, this vertical guiding axis has, under unfavorable circumstances, merely to take up horizontal thrust, so that its dimensions are very small.

Another important point in the construction of balloon sheds is the contrivance for closing the doors. Simple leaves, or folding doors, turning on hinges are inconvenient and almost immovable in even a moderate wind. They constitute likewise a constant source of danger when the airship is entering or leaving the shed. Ordinary sliding doors extend too far, and their installation is too costly.

These difficulties are avoided in Herr Unger's plan.

FIG. 1.

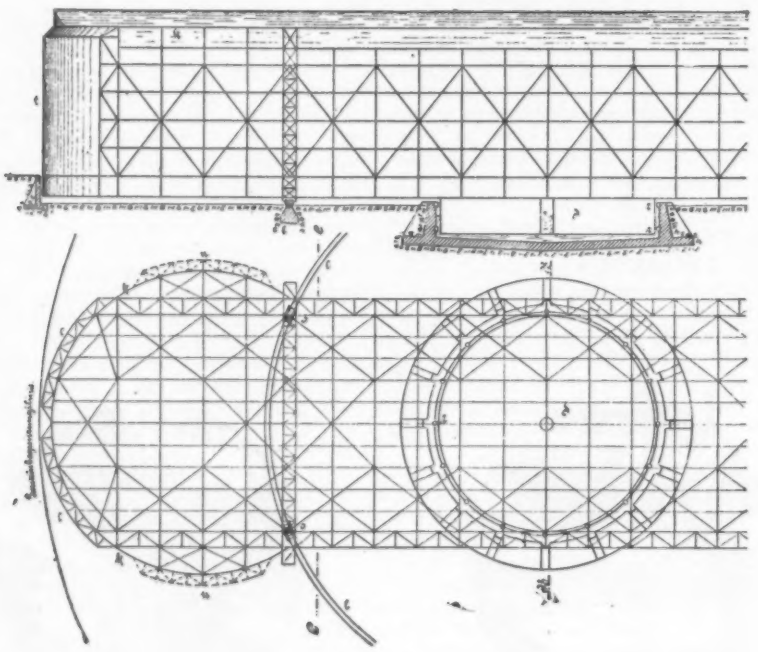


FIG. 3.

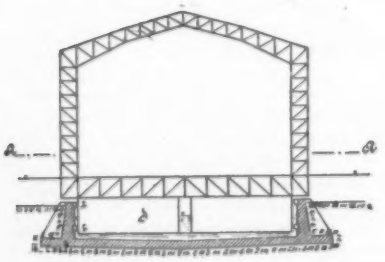


FIG. 2.

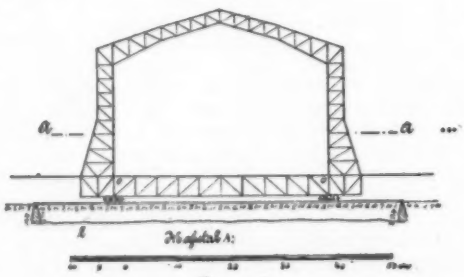


FIG. 4.

The doors form circular arches, *t*, which can be pushed into the sliding-pulley holders, *k*, which are likewise circular and are fastened firmly to the shed.

In the indicated position, *n* (Fig. 3), the doors are shoved at the side, so that the exit is entirely clear. Even in a strong wind the doors can be opened with ease and safety.

A patent for this construction has been already applied for, and it is herewith announced that the rollers may eventually be replaced by corresponding floats, which will rest on the surface of a circular trench.

The construction is of glass and corrugated iron, but the corrugated iron sheathing may be replaced by curved plates.

These, however, must be especially manufactured in a suitable size. Their use will sensibly diminish the weight of the structure, and also lend a more attractive aspect to the exterior of the imposing building.

Such balloon sheds are self-evidently particularly suitable also for flexible balloons. They will doubtless soon be erected in numbers in inland situations, especially since their cost is comparatively low with regard to that of buildings on solid foundations.—H. Kramer in Illustrirte Aeronautische Mitteilungen.

At a factory in Erfurt, Germany, India rubber is dried in a vacuum dryer which contains a number of tubes or steam plates heated with steam or hot water. Above these plates or pipes are placed perforated iron pans or racks, on which the rubber is placed. After the drying chamber is closed it is evacuated by means of an air pump, and the steam or hot water is turned on. The rubber is dried rapidly, even at a very moderate temperature, 94 deg. F., and the temperature of the mass remains low until almost complete desiccation has been obtained, and then rises slowly. The evaporated water drawn off by the pump is condensed in a surface condenser provided with means of observation. When no further moisture appears, the drying is finished. A drying chamber of medium size holds, for example, 650 pounds of sheet rubber, which is dried in two hours. The consumption of steam is very small. In general, 3 pounds of steam suffices to evaporate 2 pounds of water. This includes the steam employed in operating the air pump.

FLOWERS AND INSECTS TRANSFORMED INTO METAL.

By T. C. HUTCHINSON, D.D.S.

THE art of transforming flowers, leaves, insects, or the like, into metal, is a science which is new with this year's progress along the lines of invention, and bids fair to become very popular.

The writer conceived the idea of changing a flower or insect into metal from a little story told by an Irish dentist at a banquet table held during one of our district conventions, when he said, speaking in a jovial way of the possibilities of casting: "That he was going to quit dentistry and take up the manufacturing jeweler's business; that he was going to hire a lot of children to go into the woods to catch beetles, they to bring them to his factory, where he would stick a pin in them, invest them, and burn them out (no residue) and force metal in the form made vacant by the burning." This, in a nutshell, is my method of reproducing animal and vegetable matter in metal, differing only in that where flowers or leaves are to be cast, I use the stem of said flower or leaf as a sprue instead of a pin. While my friend little thought it possible to accomplish what he had said, yet it is true that the finest lines of the flower, viz., the ribs, stamen, and the hair-like parts of the moss rose, or the antennæ or legs of the butterfly, can be reproduced with this new method of casting with pressure.

I will in a few words tell what the dentist of to-day is doing along these lines, and from this you will readily call upon your imaginative powers the many places in which this casting with pressure will be useful to you in your work. The dentist prepares a cavity in a tooth that is to be filled, with no under-cuts; he then takes wax and fills said cavity, packs it full and trims off the surplus, so that it will be just as he wants his gold or silver filling to be; he then takes it out of the cavity, puts it on a sprue pin, and then places the pin in a crucible former, then puts a metal ring or flask over this and pours investment material, filling it up to the top of the ring. This investment material is composed of two parts silica and one part plaster of Paris. After this begins to set, the crucible former and pin are removed; this then leaves the investment with a concave surface with the sprue or hole reaching to the wax. The next procedure is to heat over a Bunsen burner slowly until the investment is freed of moisture, then the blow-pipe is used to hasten heating and to burn out the wax. When this is accomplished the metal nugget is placed in the crucible and melted to a white heat. The flask is brought in position under the metal disk of the casting machine, the latter is pressed downward upon the flask, and in so doing, automatically lets on the air, forcing the molten metal to place. This operation takes about 25 minutes. The size of the wax object to be reproduced makes little difference.

If it is possible for a dentist to accomplish this, it is possible to reproduce any form of wax, animal, or vegetable matter into metal. Wax burns out with the ordinary heat from a Bunsen, while the flower, or the like, requires a blast heat to burn up the ashes, etc. Inasmuch as vegetable and animal matter is largely composed of water, especially the former, evaporation from the heat removes the bulk of the invested flower, etc. There are many casting machines now used, having different methods of producing pressure, viz.: the air, steam, vacuum, and centrifugal force machines. I have used them all, and while any one of these will accomplish ordinary work, yet I favor the air machine for doing extensive work. The clover leaf, not much thicker than newspaper, requires more force to cast than a rose, etc. It is possible to braze one metal to another, viz., silver to gold, or *vice versa*.—Keystone.

COCOONS AND HOW THEY ARE MADE.

WHY INSECTS SPIN THEM.

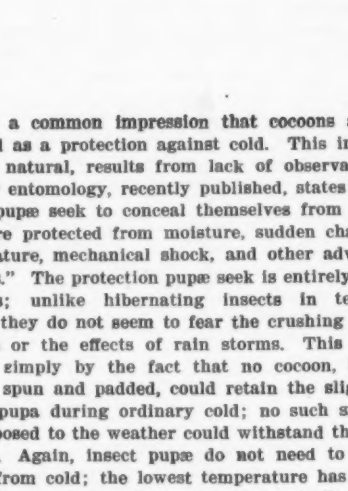
BY S. FRANK AARON.

IT is a common impression that cocoons are constructed as a protection against cold. This inference, though natural, results from lack of observation. A popular entomology, recently published, states that inactive pupæ seek to conceal themselves from enemies "and are protected from moisture, sudden changes of temperature, mechanical shock, and other adverse influences." The protection pupæ seek is entirely against enemies; unlike hibernating insects in temperate climes, they do not seem to fear the crushing of snow and ice or the effects of rain storms. This may be proved simply by the fact that no cocoon, however thickly spun and padded, could retain the slight heat of the pupa during ordinary cold; no such small object exposed to the weather could withstand the effects of cold. Again, insect pupæ do not need to be protected from cold; the lowest temperature has not the slightest permanent effect upon their vitality, which is shown by the exposed chrysalides of the butterflies, that build no cocoons, and of many moths that make only a flimsy covering. A still more satisfactory conclusion can be reached by a simple experiment: Several elegantly constructed double cocoons of the cecropia moth are chosen and placed out of doors on a cold night and with them several pupæ taken from other cocoons of the same kind and entirely unprotected. In the morning these are examined and there seems to be no difference in the stiffened condition of the pupæ. Exposed to warmth they each recover their squirming power, when touched, at about the same time, and when the weather becomes warm the moths emerge from each without difference.

Sudden changes of temperature in no way affect larvæ, pupæ, or adult insects that have not performed their natural functions, the reproduction of their kind. The writer's experiments, previously recorded, with the developmental stages and imagoes that had not laid their eggs have shown that alternate artificial freezing and thawing does nothing but suspend and return animation. Insects, therefore, have nothing to fear from the slow changes of temperature in nature nor from excessive moisture. The best illustrations of this are found in the exposed chrysalides of butterflies, as before mentioned, in the larvæ of certain moths that, not yet grown, pass the winter beneath leaves or litter, though otherwise unprotected.

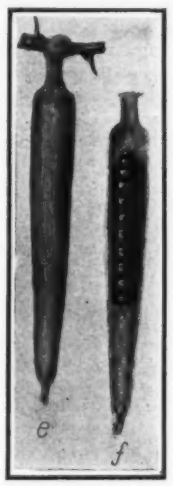
Better evidence for proving the purpose for which cocoons are constructed is found in the fact that the most perfect workmanship on the part of the spinning caterpillars to enable them to repulse their enemies is seen in the tropics, particularly among the species of Emperor moths (*Saturniidæ*) which surpass all others in silk spinning, and the bag worms (*Psychidæ*) which are the most skillful in the use of other materials.

With the numerous enemies threatening the inactive



i. Cocoons of Chrysopa, the one on the right from which the fly has emerged. Slightly enlarged.
k. Cocoons of the tomato worm parasite, as fastened to the caterpillar's skin. The flies have emerged from two, as shown. Enlarged about 5 or 6 diameters.

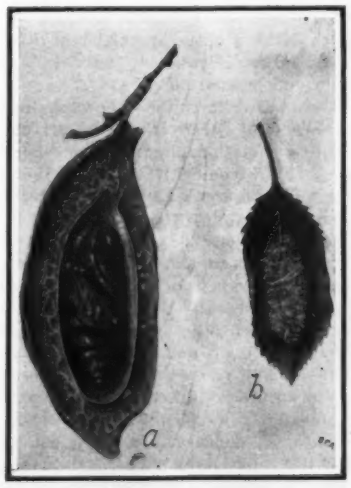
pupæ of insects it is well that nature has developed the cocoon, otherwise there would be an entire absence of many species. No doubt, however, the cocoon and the inactive stage have had a contemporary and mutually dependent development. Birds, insectivorous mammals, reptiles, and more than all else predaceous and parasitic insects are the destroyers of the inactive or lethargic larvæ and pupæ of insects and the character of the cocoon shows development against these many foes. In some cases, as with the bag worm and the clothes-moth caterpillars, the larvæ begin their cocoons when hatched from the egg. With those species that build flimsy cocoons, mere makeshifts as compared to others, and with those that build none at all, the pupæ depend upon protective resemblance to their surroundings or upon repellent odors to escape their enemies.



e. Cocoon of tropical bag worm of the United States. The texture of the outer coat is not hard, but exceedingly tough.
f. Cocoon of tropical bag worm of the United States cut open, showing the female chrysalis partly *in situ* and the lower end filled with the downy stuff in which the eggs find lodgment and which closes up the male entrance.

c. Cocoon of a tropical Emperor moth, allied to the tussah wild silk moth of Asia. This is a single cocoon, the surface being quite smooth and the texture very close and hard. Natural size.
d. Peculiar cocoon of a tropical Saturniid (Bolivia) cut open, showing the pupa within. The surface is very smooth and the texture such as to defy the insertion of a pin point by the fingers. Natural size.

But, however excellent the cocoon making may be, it seems to serve only half a purpose—to guard only against the birds and predaceous insects that attack the pupal stage. As against that great army of destroyers, the parasitic insects, the making of the cocoon is most often like locking the barn door after the horse is stolen; the mischief is done before the



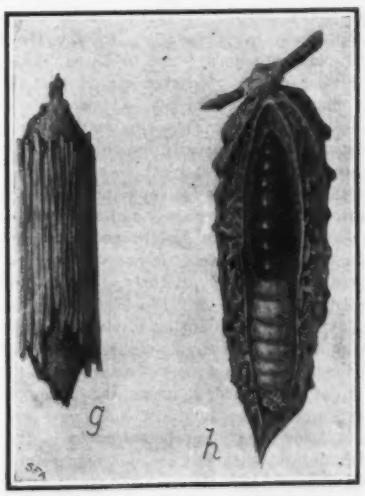
EXTREMES.

a. Double cocoon of Saturniid moth larva from Brazil, the most complex and perfect construction for its purpose. The chrysalis *in situ*.
b. Cocoon of the common tussock moth of the United States in a pear leaf. The chrysalis may be plainly seen within. Natural size.

caterpillar spins its cocoon, so that the poor host of a voracious body tenant is doomed when it makes its cocoon, though its vitality and instincts are not, for the time, much dimmed. In such case, however, there is a falling off in excellence of workmanship on the part of parasitized larvæ, so much so that the cocoons of such may be picked out with ease from others. The parasites are truly the balancers of nature, and they most frequently prevail. Out of 169 cocoons of various species of Emperor moth, the cecropia, polyphemus, luna, promethea, etc., collected in one season, 142 contained parasitic insects, while only three were taken that had been torn open, evidently by the bills of birds. (It is said that the small woodpeckers can effect an entrance even into the cecropia cocoon, but if so Picus must have a job on his—bill.) Out of 32 cocoons of the Ailanthus silk worm, *Philosamia cynthia*, 26 were parasitized. This and the above are a fair average. There are certain parasitic insects (*Ichneumonidæ*) that have long and keen ovipositors, and these puncture the toughest cocoons and lay their eggs in the helpless pupæ within.

The making of cocoons is the spinning of silk, in which are employed the glands near the mouth parts which yield a glue-like liquid that hardens into threads as it is strung from place to place. These threads, when soft, are naturally adhesive, but in addition the strands are made tougher and more compact by a thinner glue-like substance called sericin, taken from other glands and exuded with the silken strands and also spread over them. The spinning caterpillar places its silken threads in loops upon the inner surface of the cocoon, these loops generally taking the form of the figure 8 or of acute angles, and overlying each other. The domestic and wild silk worms make a continuous and uninterrupted series of loops so that the sericin may be softened and the strands unwound (reeled), becoming then the raw silk of commerce. Other cocoons even more complicated, thicker and larger, with the strands as fine and even, cannot be unwound because the strands are tangled with the coatings of sericin, and this cannot be softened sufficiently to free them.

Although cocoons are of the same general character, a closed pocket in which the insect rests during its growth from worm to imago, there is to be found a wide difference in appearance and architecture. Some species of the *Saturniidæ* make double cocoons, not using the term as the silkworm raiser does, where two caterpillars build a cocoon together. There is a cocoon within a cocoon, the outer one spacious, loose and wrinkled, but not the less tough, the inner one having the shape and character of the typical elliptical casing in which the pupa rests. The well-known cocoon of the great cecropia is the best constructed example of this to be found in temperate climes; the tropics furnish others more perfect still, having a sort of loose, padded network between the outer and inner coatings (*a*). The contrast to this is the cocoon, if it may be so called, of the common tussock moth of the Northern States (*b*), a mere webbing back and forth in leaf or bark crevice and in which are mixed the hairs



g. Straw coated cocoon of tropical bag worm (Bolivia). The silken material is tough but pliable.
h. Cocoon of tropical bag worm, closely allied to the common United States species. Cut open showing the female having emerged from the chrysalis.

of the caterpillar. This is only sufficient to hold the pupa in place; its enemies are held in check by its repulsive odor, although they frequently attack it. The cocoons of the commercial wild silk worms, the tussah of India and its unused allies of several semi-tropical regions, are peculiar in that they hang from a stem, often nearly as long as the cocoon itself (*c*).

There is often a great deal of sericin in their tex-

ture and the silk is closely overland, making them very tough and hard. The most remarkable cocoon in this respect is that of a small species found not uncommonly in the forests of the Upper Amazon and its tributaries (*d*). It is a Saturnlid, but of what species is not known. The cocoon often hangs horizontally and at right angles from the thick stem and the exit of the moth is properly a part of the stem. The material is so hard and tough as to make it impossible to force a pin through it by the head; if the fingers are strong enough the pin will bend. This nut-like case would almost seem to be impervious to the attacks of bird or ichneumon fly. However, some of the latter pierce oak and hickory for several inches and some of the parrots might use their bills successfully upon it. (The writer had his thumb pinched once by a parrot; a cocoon might even be of thin iron and succumb.)

The bag worms employ not alone their silk-spinning powers. Stems and parts of leaves, twigs, bits of bark and other material are used to mix with or lay over the silken strands. Our own common species, *Thyridopteryx*, covers the outside of its "bag" with bits of leaves and stems, and an examination of its cocoon will often determine upon what tree the caterpillar lived. Some of the tropical bag worms (they are sometimes called basket worms) have very remarkable larval and pupal cocoons. Several species build a long, narrow case not unlike a cigar in shape and color, the texture very tough, one of which is shown at *e* and *f*. Another covers its cocoons with bits of grass stems, cutting the straws off the desired length and arranging and fastening them in regular form so as to complete the cylinder (*g*). Still another makes a double cocoon and fills the space between them with sticks, the stems of leaves cut very short (*h*). In doing this it may spin the outer coat, then drag the sticks within it, and after thus coating the inside line the whole with the inner case. Or it may make the inner case first, cover it with sticks and then reach far enough out to spin the outer coat over all. The result is certainly a tough, almost impregnable protection, and shows the height of skill in cocoon making. The cocoons of most moths are, in general, not unlike that of the tropical races of the domestic silk worm, a non-rigid, elliptical case, more or less thick, with outer strands holding it in place. Some are pure white in color, others pale or dark brown, some greenish or dull red, none of varied or high color. Some caterpillars cut away the bark of the tree or the dead wood so as to imbed the cocoon in it at least half way; others seek a hollow stem or other narrow cell and conform the cocoon to its shape.

Gregarious species often build a mass of cocoons closely united, the outer strands inextricably entwined one with another so that it appears rather more like a common cover over all than separate cells. The silk-spinning habit is common with all nocturnal Lepidoptera. None, in fact, are without it, even those that burrow in the ground, as the hawk moths (*Sphingidæ*); for, upon forming the earthen cell at the end of the caterpillars' downward burrow, they line this with a thin layer of silk varnished with sericin that is often shining black.

Many insects besides the Lepidoptera are silk spinners; excepting nearly all of the Diptera and many Coleoptera, insects of the orders having inactive pupæ employ this power either to make cocoons or to line their pupal retreats.

The sawfly slugs (*Tenthredo*) line their earthen pupal cells with a shining, silken coat that is often a very compact and pretty structure; many burrowing beetle larvæ, as certain weevils (*Curculionidæ*) and leaf beetles (*Chrysomelidæ*) do the same, but less perfectly. The parasitic Hymenoptera (*Ichneumonidæ* and *Braconidæ*) are often excellent and independent cocoon builders, the larger species nearly always covering themselves with fine, parchment-like silken cases made within their larval and pupal retreats, while the small, almost microscopic species make cocoons that in miniature greatly resemble those of the domestic silk worm; they have the same shape, color (white and yellow), and texture (*k*). Some of these also build an irregular parchment-like pupal case within or contiguous to the insect in which they passed their larval existence. The bees, wasps, hornets, and ants and the solitary hornets, as the mud-daubers, the diggers, etc., nearly all make cocoons within their nests and the cells thereof; these are also parchment-like. The so-called eggs of ants, often seen being carried from an exposed ant hill, are the cocoons of the helpless larvæ, and by opening a mud wasp's nest the brown, thick-at-one-end cocoons may be extracted that are nearly typical of those of the solitary Hymenoptera.

The caddie flies (*Trichoptera*) are excellent cocoon builders; the larvæ and pupæ under water are not alone protected by tough cases but they are fashioned with a resemblance to shells, stones, sticks, etc., and often these articles are used in the effort to make the cocoons unseen. Tiny pebbles are fitted together so closely as to leave hardly a visible opening between them; small sticks are fenced around in three-corner pig-pen fashion, or like bundles, end to end, cut all of a length, and the interiors of these cases are lined thickly with silk and a head-end pliable opening is extended that can be drawn in and closed.

The useful larvæ of the golden-eyed, gauze-winged flies (*Chrysopidæ*) are cocoon builders, their small, nearly round, silken balls resembling pills fastened to a leaf. They are cut open evenly at one end, permitting a lid-like opening for the exit of the fly, similar to the cocoons of Apanteles. It is here remarkable that the insect spins its cocoons from anal glands and not by the mouth-parts.

The larva of the flea, in chinks and crevices, makes a flat, spread-out pupal covering, the floor of which is the object to which it is attached, appearing more like a low, silken tent than a true cocoon.

THE DURATION OF LIFE ON THE EARTH.*

THE INFLUENCE OF SEA AND CARBON DIOXIDE.

BY J. C. GREGORY, B.SC., A.I.C.

It has been calculated that the combustion of coal throws every year into the atmosphere 2.4 x 10^9 tons of carbon dioxide. If this figure is accepted, it works out to about 76 tons per second. On an average, then, there is an addition of about 76 tons of carbon dioxide to the atmosphere from the burning of coal in every second of time. If these 76 tons of carbon dioxide were all massed together under average atmospheric conditions they would occupy about 8,616,000 gallons. Carbon dioxide being about one and one-half times as heavy as air, it might be thought that all the gas thus poured into the air would tend to settle to the bottom of the atmosphere and form a thick layer on the surface of the earth. In the well-known Poison Valley of Java, the accumulation of carbon dioxide tends to suffocate animals that enter it. In the Grotto del Cane near Naples dogs are apt to be asphyxiated by the underlying layers of carbonic acid gas. The exceptional character of such places, however, tends to prove that atmospheric carbon dioxide does not form a bottom layer. The gas really spreads itself throughout the atmosphere.

Now although there is a constant flow of carbon dioxide into the air from organic and inorganic sources, the total amount of this gas in the atmosphere remains remarkably constant. It appears to be increasing slightly, but only very slightly. The total amount of carbon dioxide in the air has been computed to be about 1000 times the quantity produced annually by the burning of coal. Its total weight is therefore about 2.4 x 10^{12} tons. The most recent estimate of the total population of the world suggests the figure 1.5 x 10^9. For every human being in the world, there are, therefore, about 1,600 tons of carbon dioxide in the atmosphere. Compared with the amount of carbon dioxide expired by the total population of the world in one year, the total amount of carbon dioxide in the atmosphere is very great. Roughly speaking, 1,000,000 human beings expire about 2.5 tons of carbon dioxide in one hour. This is only an approximate figure, but it is enough to indicate that the respiration of the population of the globe would take a long time to produce the total amount of atmospheric carbon dioxide. According to this figure, the 1.5 x 10^9 inhabitants of the globe daily expire 90,000 tons of the gas. This would amount to 32,850,000 tons in one year. Approximately 71,000 years would therefore elapse before the total amount of carbon dioxide in the air could be obtained by the breathing of the present population of the globe. In this approximate calculation, no account is taken of the respiration of beasts.

The carbon dioxide produced from all sources and poured into the atmosphere tends to mix uniformly with the other gases of the air. But just as cold water from the North Pole or the warm waters from the Gulf Stream constitute definite currents before they are completely mixed up with the main body of oceanic water, so there tends to be a larger proportion of carbon dioxide in the neighborhood of the places where it is generated. Thus in the air of the Grotto del Cane there is a relatively large proportion of carbon dioxide. It takes time for the generated gas to diffuse away and scatter uniformly through the atmosphere. In the same way the proportion of carbon dioxide is greater in the neighborhood of cities and towns than it is in unpopulated districts.

This is more particularly the case in the rooms and houses of towns and cities. When the carbon dioxide breathed out by their inhabitants is more or less shut in by doors and windows, it naturally takes longer for the gas to diffuse away. One object of ventilation is to hasten the mixing of the expired carbon dioxide with the main body of the atmosphere. To a person entering from the open air, a room begins to "feel close" when in every 10,000 cubic feet of air there are six feet of carbon dioxide. Under these circumstances the amount of carbon dioxide contained in a room 50 feet long, 10 feet high, and 20 feet broad would be about equal in volume to a ball 11 4/5 inches in diameter. It is usual to take this as the maximum amount of carbon dioxide allowable. This proportion of the gas is perhaps not dangerous in itself, but it acts as an index of the pollution of the air. It is the volatile organic matters expired along with the carbon dioxide that make the room unhealthy. Most people suffer from headache and depression in an atmosphere containing 15 cubic feet of carbon dioxide in every 10,000 cubic feet of air. Too great a proportion of carbon dioxide is, of course, in itself inimical to health; and a great excess will produce suffocation. But the usual effects of vitiated atmospheres are mainly due to other products of decomposition. The smell of such vitiated air is due to these "volatile ptomaines."

It is an interesting fact that the proportion of atmospheric carbon dioxide is usually greater on mountain tops than lower down. At the top of Mont Blanc the carbon dioxide is present in more than one and three-quarter times its average proportion. Ordinary air contains, on an average, rather more than three and one-quarter pints of carbon dioxide in every ten thousand pints of air. In every ten thousand pints of air at the summit of Mont Blanc there are about six pints of carbon dioxide. The proportion of carbon dioxide at the top of Mont Blanc just about reaches the limit below which it is considered desirable to keep the carbon dioxide in rooms. In the case of the mountain air, however, the carbon dioxide does not indicate respiratory pollution, and is probably connected with the comparative or total absence of vegetation. Carbon dioxide is a food of green plants, and where there is much vegetation it is accordingly drawn off from the air. By means of the green coloring matter (called chlorophyl), and assisted by the sunlight, plants remove the carbon from the carbon dioxide and breathe out the oxygen again. Since sunlight is necessary to enable plants to do this, the proportion of carbon dioxide in the air usually rises at night. Foggy weather often produces a slight increase, which may be partly due to the cutting off of the sunlight.

The constant withdrawal of carbon dioxide from the air by plants helps to balance its emission into the air from all the various sources. Although the amount of carbon dioxide in the air appears to be slightly increasing, there is a striking constancy in its total amount. It seems very remarkable that the influx and efflux of the gas into and from the air should so well balance one another. It has recently been pointed out that the sea acts as a regulator of the amount of atmospheric carbon dioxide. It does this by dissolving a proportion of the excess of the gas over the normal amount; and, under certain circumstances, restoring some to make good any deficiency.

In view of the relatively great disturbance of the balance between the carbon dioxide emitted into and withdrawn from the atmosphere by the burning of coal, this regulative effect becomes an important factor in the economy of Nature. Many investigators think that a doubling of the proportion of carbon dioxide normally present in the atmosphere would almost render the air unfit for continued respiration. As already seen, about 71,000 years would elapse before the respiration of the present population of the globe would convert the approximately 3 volumes of carbon dioxide per 10,000 of air into twice that amount. Since the carbon dioxide produced annually by the combustion of coal appears to be about 0.001 of the total vol-

* Knowledge and Scientific News.

ume in the atmosphere, 1,000 years of coal consumption at the present rate would produce the same doubling. Assuming that the action of vegetation, etc., fairly well balances the effects of respiration, decay, and other processes that pour carbon dioxide into the air, the relatively great production of the gas by the combustion of coal might become a serious matter.

To understand the regulative action of the sea imagine a cubical vessel having a capacity of 20,000 cubic feet. If this vessel is half full of pure water and half full of air it will contain 10,000 cubic feet of each. Suppose that the vessel is completely closed in, and that the air contains three cubic feet of carbon dioxide. That is, if all the carbon dioxide spread through the air were collected together it would occupy three cubic feet. This amount represents, approximately, the average amount of carbon dioxide in the air. The air, including the carbon dioxide, will proceed to dissolve in the water. The dissolved air will gradually spread through the water until the water has dissolved as much as it can take up. Two processes are really concerned. In the first place air dissolves in the water—passing from the space above into the water. At the same time, some of the dissolved air escapes from the water into the upper space. As long as more air passes from the space above to the water than from the water to the space above, the water continues to extract air from the upper space. It is evident that as long as the dissolved air continues to increase in amount, the amount of air escaping from the water in a given time will continue to increase, because there is more air to escape. In course of time the two processes balance one another—the exports ultimately equal the imports—and the water now contains as much air as it can take up (under the circumstances). When this equilibrium is attained, the pressures exerted by the dissolved and atmospheric air are equal to one another.

Now consider the carbon dioxide alone—ignoring the other gases. As a matter of fact, the carbon dioxide behaves just as if it alone occupied the whole space. When the water has taken up—dissolved—as much carbon dioxide as it can, about one and a half cubic feet of the gas is dissolved in the water and the remaining one and a half feet remains in the air above. If there had been six cubic feet of carbon dioxide to begin with, three of these would have been dissolved in the water. The water and the air above contain about half each of the carbon dioxide. This is when the volumes of the water and air are equal. If the volume of the water were twice that of the air, it would dissolve about two-thirds of the carbon dioxide; and the remaining third remain in the air, and so on. If now a little more carbon dioxide is introduced into the air above, some more dissolves in the water until it is again equally divided between the equal volumes of water and air. If a little carbon dioxide is removed from the air above, some carbon dioxide escapes from the water until the remaining gas is again equally divided between the water and the air. Thus the water tends to keep the amount of carbon dioxide in the air above constant, dissolving more when the amount increases and giving up some when the quantity decreases. It cannot, of course, keep it perfectly constant, but if there is a very large quantity of water it can do much in this direction.

The very large total volume of the sea has a very considerable effect in maintaining the constancy of the proportion of carbon dioxide in the air. It has been calculated that the sea contains about twenty-seven times as much carbon dioxide as the atmosphere. The amount of carbon dioxide absorbed by the sea is affected by the salts dissolved in it, so that the preceding paragraphs do not give a complete account of the matter. The water of the North Atlantic has been shown to contain 49 cubic centimeters of carbon dioxide per liter. This is equivalent to 400 parts per 10,000. This carbon dioxide contained in sea water may be for practical purposes divided into two parts, one being regarded as existing in combination as carbonates or bicarbonates and the other being free to diffuse through and out of the water just as in the case of carbon dioxide dissolved in pure water. These two portions are not absolutely unconnected; it is well known that bicarbonates like those of sodium and calcium tend to decompose in solution, and that excess of carbon dioxide converts some carbonate into bicarbonate, but sea water always contains some free carbon dioxide.

Equilibrium between this free and the atmospheric carbon dioxide is attained when the pressures of the two are equalized. As just seen, in the case of pure water the pressure of the dissolved carbon dioxide becomes equal to the pressure of the atmospheric carbon dioxide when the volume of the dissolved gas per liter of solution is practically equal to its volume in a liter of air. A constant interchange thus takes place between the surface of the sea (and of other waters) and the air above it, according as the pressure of the carbon dioxide is greater in the air or in the water. Any deviation from the normal proportion of carbon dioxide in the air produces a compensating effect by altering the pressure of the atmospheric portion of the gas which results in absorption by the sea of some of the excess, or in the introduction of some of the dissolved gas into the air to make good the deficiency. Investigation appears to indicate that the pressure of carbon dioxide is less over the surface of the sea than over the land. If this is so, the accumulation of carbon dioxide in the air may be regarded as being continuously retarded by the constant absorption by the sea of any excess over the normal quantity. Since the presence of any considerable excess of carbon dioxide over its present amount might seriously interfere with animal life, it is evident that the sea may play a very important part in determining the length of the period for which the earth can continue to be habitable by man.

Correspondence.

THE WADAGAKI STEAM TURBINE.

To the Editor of the SCIENTIFIC AMERICAN:

The article in the SUPPLEMENT of May 29th, page 339, on turbine propellers interested and surprised me. It would seem, to an engineer up a tree, that the obvious way to transmit the motion of the steam turbine to the propeller, at any desired proportion of speed, would be by means of water (with a suitable lubricant in solution) forced by a rotary pump connected with the turbine shaft, to a motor on the propeller shaft. Of course, oil might do, though its superiority is doubtful. Properly arranged, the loss in transmission should be very moderate. Furthermore, the relative speed of the propeller could be perfectly regulated by a side valve for letting part of the fluid from the pump into the return pipe without entering the motor. This, theoretically at least, involves no loss of power, except to the propeller.

S. TIDEMAN.

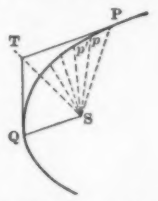
Peru, Ill.

PROOF THAT A CONIC SECTION MUST BE DESCRIBED UNDER GRAVITY.

To the Editor of the SCIENTIFIC AMERICAN:

To prove that a particle, moving under the action of a central attractive force which varies inversely as the square of the distance, describes a *conic section* of which the center of force is a focus:

Let S be the center of force, P the position of the particle, and PT its direction of motion at any moment. Also let Q be the position of the particle and TQ its direction at a subsequent period.



Suppose the angle PSQ to be divided up into an indefinite number of minute *equal angles* pSp'.

Denote

any length Sp by r

and the force along Sp by f

Then, by hypothesis

$$(A) \qquad f \propto \frac{1}{r^2}$$

Now, since the angles pSp'....at S are *equal*, we have area of $\triangle\ pSp' \propto r^2$.

But, by a general law of motion the area of $\triangle pSp'$ is proportional to the time (t) taken to describe it.

(B) Hence $t \propto r^2$

Multiplying (A) and (B) we have $ft \propto \frac{r^2}{r^2}$, that is, is *constant*.

In other words, while the particle describes *equal* minute angles about S, it is acted upon by a *constant* amount of force directed toward S; and it is not difficult to see that the *resultant* of all these evenly-distributed equal forces must be through S, and must *bisect the angle PSQ* traced out by this particle.

But this resultant, inasmuch as it effects a change of motion in the particle from PT to TQ must pass through T.

Hence, *TS bisects the angle PSQ*, which is a general property of *conic sections* with S as a focus.

IMMO S. ALLEN.

London Institution, Finsbury Circus, E. C.

THE CURIOSITIES OF NUMBERS.

To the Editor of the SCIENTIFIC AMERICAN:

It is curious that the writer of just the very article that absolutely denies the curiosity of numbers and emphasizes the rigid truth of mathematics at the same time commits himself by demonstrating the greatest of all the curiosities any of the other articles that have come under my notice as yet have revealed.

In the SCIENTIFIC AMERICAN of April 10th, Mr. D. M. Morris, while in the act of explaining the mystery of how it is that the sum of the 9 digits, doubled, and the last term deducted from the product, equals the square of the last term, states that the sum of any like series is half the sum of the first and the last terms divided by 2 and multiplied by the last term.

I am sure that many of the readers of the SCIENTIFIC AMERICAN who are less advanced in mathematics must consider the above statement rather emphasizing the theory of curiosity of numbers, whereas those better acquainted with said science soon see what Mr. Morris really means to say.

As the case in question is the simplest application of arithmetical progression, the formula is written

$S = \frac{n\,(a+n)}{2}$ where a is the first term, n the number

I have no doubt that Mr. Morris knows different from Mr. Morris the same formula would look like this:

$S = \frac{n\,(a+n)}{4}$ which of course is wrong.

I have no doubt that Mr. Morris knows different from what he writes, but it is hard refraining from pointing out a serious error in a statement of this kind, especially where it takes the form of censure. Great care should be taken in putting explanations correctly and very plainly.

N. TH. SJÖSTEDT.

Shanghai, China.

ESTIMATION OF NITRATES AND NITRITES IN WATER.

THE nitrates and nitrites contained in water can be estimated either together or separately. The reagents which act similarly with both compounds include:

First. Diphenylamine sulphate, a few drops of which in presence of a drop or two of the nitrated water and of 1 cubic centimeter of sulphuric acid produce a blue coloration, which shades into yellow if the solution is too concentrated.

Second. Carbazol, or diphenylene-imine, which gives a bluish-green color.

Third. Brucine, which gives a fugitive red color.

Fourth. The reagent of Grandval and Lajoux, consisting of sulphuric acid with 7 per cent of phenol, which is employed as follows:

To one drop of suspected water 1 cubic centimeter of the reagent is added. Distilled water is added to make 8 or 10 cubic centimeters and ammonia is then added in excess. The result is the formation of ammonium picrate, which colors the liquid yellow. In order to estimate the nitrates and nitrites, 10 cubic centimeters of the water is evaporated to dryness, and the residue is wet with 10 drops of the reagent and a little water. Ammonia is then added in excess, and the mixture is diluted to 50 cubic centimeters. The tint obtained is compared with a scale of tubes containing solutions prepared by diluting a standard solution of potassium nitrate which has been treated with the reagent in the same manner.

The reagents used for the estimation of nitrites alone are:

First. Antipyrine, which gives, with nitrites and sulphuric acid, a green or bluish green coloration, due to nitroso-antipyrine.

Second. The reagent of Griess, sulphanilic acid and naphthylamine. This reagent produces a red color with nitrites, but is too sensitive for ordinary work.

Third. Aniline acetate, giving a blood-red color in presence of nitrites and sulphuric acid at the temperature of ebullition.

Fourth. Metaphenylene-diamine hydrochlorate.

Fifth. Potassium iodide and starch.

Tabuteau recommends the last two reagents, for example: To 10 cubic centimeters of a solution of silver nitrite containing 0.406 gramme per liter are added 5 drops of a solution of 1 part of metaphenylenediamine hydrochlorate in 200 parts of water and 5 cubic centimeters of a 10 per cent solution of sulphuric acid. The mixture is shaken and heated to boiling over the water bath. A brown coloration is produced by the formation of Bismarck brown. The mixture is then diluted to 500 cubic centimeters; 50 cubic centimeters of the liquid is placed in a tube and gradually decreasing quantities are placed in other tubes, which are filled up with water to 50 cubic centimeters in order to obtain a scale of comparison. The same operation is repeated on the suspected water, and the tint produced is compared with the scale thus established. The proportion of nitrites in the water can be obtained by a very simple calculation. In the starch iodine method 100 cubic centimeters of the water are mixed with 20 cubic centimeters of 10 per cent hydrochloric acid and 2 or 3 cubic centimeters of starch paste. Nitrous acid and oxygen are disengaged. Four or five grammes of potassium carbonate are added, causing an evolution of carbon dioxide which expels the oxygen; 20 cubic centimeters of a solution of potassium iodide is then added. The blue coloration produced by iodine in presence of starch appears, and the quantity of iodine set free can be titrated with sodium hyposulphite.

ELECTRICAL NOTES.

In 1904 Lenard proved that falling rain drops more than 0.23 inch in diameter are in unstable equilibrium, and soon divide into smaller drops. He showed also that these smaller drops cannot fall faster than 26 feet per second. Hence no drops can fall at all through an ascending air current which has a greater velocity than 26 feet per second. Drops larger than the critical size are broken up, and their parts, together with the originally smaller drops, are carried upward by the air current. From these facts Simpson has evolved a new theory of thunder storms during the occurrence of which he regards the existence of rapid upward currents as extremely probable. According to this theory the rain drops, which are incessantly subdivided as soon as they attain the critical dimensions, accumulate at a certain elevation. Now, experiment has proved that when drops are thus subdivided they become positively charged, while the negative ions are carried away by the air current, which thus acquires a negative charge. The suspended mass of water may undergo these changes many times, and thus acquire the high positive charge which is shown by freshly-fallen rain water. The negative ions carried upward by the current are absorbed by the clouds, which thus become negatively charged. The electrical phenomena of thunder storms result from occasional equalizing discharges between the negatively electrified clouds and the positively electrified suspended drops.

The Reithofer-Morawetz system of wireless transmission of time signals has been tested in Vienna for several years and has proven so satisfactory that a general introduction of the system is in contemplation. The experimental plant includes a sending station and three receiving stations in various parts of the city and suburbs. In the sending station a wheel bearing 60 teeth is advanced one tooth per second by means of an accurate seconds pendulum. Once in each complete revolution, and consequently once in every minute, the wheel closes the circuit of the wireless transmitter. At the receiving station the aerial waves affect the circuit of an electric clock and move the minute hand through one division. The circuit is then automatically broken and remains open until ½ or ¼ second before the arrival of the next minute signal, when it is automatically closed. This device prevents serious disturbance by waves from other wireless stations or by atmospheric electricity. Any disturbance which may occur during the short interval in which the clock circuit is closed can only cause the minute hand to advance ½ second, or less, too soon. As soon as the hand has advanced the circuit is broken, so that the waves from the time station which immediately follow have no effect and the hand does not again advance until the arrival of the following minute signal. Hence, though an individual minute may be shortened or lengthened by a fraction of a second, no permanent or cumulative error is introduced.

Unipolar dynamos are ideally simple machines for producing a non-pulsating direct current. Their development from the experimental disk dynamo of Faraday to the modern commercial machine has been an interesting triumph over the limitations to which the acyclic generator is subject. While one of the earliest forms of the dynamo-electric machine, the progress of the unipolar type had not, until comparatively recent years, kept step with the development of the commutating dynamo. Difficulties of obtaining the high speeds necessary in a reasonable field strength and the problem of collecting the large currents at the low voltages for which the machine is particularly adapted, while the armature collector rings were traveling at such an extreme velocity, have tended to hold the unipolar machine behind the general progress that has occurred in electrical generators. But the advent of the steam turbine, with its high rotative speeds, has resulted in a revival of interest in the possibilities of the homopolar design, until now this type of generator, which might only have been hoped, a few years ago, to supply large low-voltage currents for electrolytic and metallurgical service, has taken a place in the power and light field, supplying current at pressures ranging up to 600 volts. To the electrical man familiar with the commutating dynamo, the new types of the acyclic machines will present some anomalies. Conductors such as are usually employed in armatures do not exist, and in the armature are loose contacts, made necessary by the expansion of the long collectors, which depend upon the high centrifugal strains during operation for maintaining a good electrical contact. At the peripheral speeds of the order of 25,000 feet per minute at which the current is collected it was necessary to devise a new two-metal brush, as the ordinary copper brush would wear several inches during a day's operation. Overloads of 200 per cent and more have been carried by these new generators without affecting the working, and heavy short-circuits in the external circuit have caused no damage to the machine. Contrary to the first assumptions, recent high-speed experimental machines have shown that the losses due to the collection of current increase only slowly with increase in speed after the higher speeds are attained. Incidentally, the high speeds result in increased ventilating facilities.—Western Electrician.

ENGINEERING NOTES.

Except where high tensile strength is essential, copper makes the best hardening adjunct to aluminium, owing to the excellent pouring properties of the alloy, the contraction being low and the metal free from the tendency—characteristic of aluminium-zinc alloys—to crack in the mold. The high melting point of the copper renders it inadvisable to melt the two metals together, as the castings are liable to be spoiled by air bubbles. The better plan is to melt the copper first in a graphite crucible, covering the surface with charcoal, and then to add an equal weight of aluminium by degrees, the mixture being stirred between times and becoming white-hot in consequence of the thermal reaction. When poured into molds, this alloy is white and brittle, and can be crushed with a hammer. To harden ordinary aluminium-copper alloys—e. g., the usual casting alloy containing 42 parts Al and 3 Cu—with the 1:1 alloy, all that is necessary is to heat 39 parts of the former and 6.3 parts of the latter in a crucible and stir the mass.

In a recently-issued report by the British Fire Prevention Committee particulars are given of a test conducted in January last upon a door consisting of four layers of deal, each ⅞ inch thick and covered completely with tinned sheet steel of No. 26 S. W. G., the door being fixed in an opening through the wall of a test hut. The object of the test was to ascertain the effective resistance of such a door when exposed to the action of fire at a temperature gradually increasing to 1,800 deg. F. and for a period of two and a half hours. Briefly summarized, the results were as follows: In forty-three minutes flame appeared between the door and the brickwork at one side; in fifty minutes the door warped away from the brickwork at the top to the extent of 1 inch, thereafter the door bent inward until, in 145 minutes, the top part was 16 inches away from the surface of the opening; and at the conclusion of the test the interior woodwork was found to be consumed. The test made clear the point that, however useful a door of this type may be for arresting the progress of a fire during the early stages, it cannot afford material protection for very long.

Following the example of the United States some of the leading railroads of Europe have taken up the question of wrecking cars which are fitted with heavy cranes in order to remove wrecked locomotives or cars from the tracks in an efficient manner. A type of wrecking car has been brought out in France within a recent period by the Orleans Railroad Company, and it is now in regular service. The crane is operated by steam in this case. The crane is of the 50-ton size, and is thus able to lift nearly all the heaviest locomotives and cars. The crane-car is mounted on double bogie so as to pass around curves readily, and is drawn by a locomotive. In the rear is attached a repair car fitted out with all the needed tools. A specially trained crew is attached to the wrecking train which is thus formed. The cranes are of French construction and have been already brought into use in practice. Some of the other railroad companies, such as the State and West railroads, called upon the new wrecking train in cases of need. When not otherwise employed, the train can be put in use for various purposes, such as replacing small bridges, loading and unloading of material, construction work, and other uses.

For thirty-two years compressed air has been used in the general transportation system of a cordage company at Plymouth, Mass., whose buildings cover an area of 2,500 x 1,000 feet. The compressed air system is simple; no expert knowledge is required nor expert handling of the apparatus; no mechanic who has had any experience with steam finds perplexing details arising in connection with repairs, and the manipulation of the locomotive is readily acquired by an intelligent laborer. The cost of repairs is very slight. The first locomotive at the Plymouth plant was purchased in 1876 and has been in active service continuously ever since, with a surprisingly small amount spent on it for maintenance. The locomotives are charged at various points about the plant. The charging valves are located particularly with the idea of having the tank filled at the same time that the cars are being loaded or unloaded. Some of the runs are quite long, the longest being 2,400 feet, and the round trip under favorable weather conditions is made with one charge. On this run a net load of 8,500 pounds is carried and the cost of air figures 0.04 cent per ton per 100 feet. Other runs figure 0.08 cent per ton per 100 feet. This cost is based on a cost of ½ cent per 100 cubic feet of free air and includes all charges up to delivering the air into the mains at 200 pounds pressure; these figures are on the conservative side. The system as a whole, taking lump figures, moves 1 ton, net load, 100 feet for approximately 1 cent. This includes the air used for all other purposes, fixed charges on all the rolling equipment as well as compressing apparatus, and all attendance.—Iron Age.

TRADE NOTES AND FORMULÆ.

White ink, for writing on white paper, is obtained by mixing fine white lead or Krems white with the finest pulverized gum arabic and distilled water, rubbing together thoroughly, for instance, 15 parts of white, 1 part of gum arabic, and 35 parts of water.

Vulcanite (of Gitschin) is composed of 36 parts nitrate of potash, 19 parts nitrate of soda, 11 parts sulphur, 9 parts sawdust, 9.5 parts chlorate of potash, 6 parts wood-charcoal, 4.5 parts Glauber's salt, 2.25 parts red prussiate of potash, 2.35 parts sugar, 1.25 parts picric acid.

Silver-plating Copper Vessels for Fruit Juices.—12 parts cyanide of potassium, 6 parts nitrate of silver, 30 parts calcareous spar, mixed and finally pulverized, and the copper rubbed with it until it is bright and white. Rinsing with water readily removes any remaining particles of cyanide of potassium.

Apple Butter.—Under this name a thick apple jam is prepared that can be kept for years and is used as a spread for bread. The apples are pared clean, quartered and the core husk removed. The cut-up apples are then placed in a kettle with some fresh, sweet fruit juice and boiled down to a paste having the consistency of butter, filled into jars, some melted lard poured over the surface and set aside in a cool place. The apple butter can be made more appetizing and tasty if, toward the end of the boiling, some pulverized cinnamon and finely cut lemon peel are added.

Paint for the Protection of Cement from Acids.—In the preparation of such a paint, take pure asbestos, pulverized as finely as possible, and mix it with a solution of silicate of sodium, as alkaline as possible. The asbestos is first rubbed up with a small quantity of the silicate until a dough-like mass is obtained, which is preserved in well-closed vessels. Before use, this paste must be thinned down with the silicate solution, until a sort of paint is obtained, 2 to 3 coats of which will protect the walls of the reservoir, etc., from acids, either solid or fluid. The mass may also be employed for coating sandstone.

Wax Color for Floors.—I. Yellow. 7½ parts caustic soda lye and 2½ parts of yellow wax are boiled together and 1½ to 2 parts of finely-pulverized ocher mixed with it and stirred to make a homogeneous mass. II. Red Brown. For the above decoction, 2 parts of finely-pulverized umber can be used and thoroughly mixed in. III. Nut Brown. ½ part orlean, 1 part each burnt umber and yellow ocher, give, when mixed according to the foregoing directions, a beautiful red-brown color. The finished mass, when required for use, is mixed with sufficient hot water to convert it into a thin syrup and then applied with a stiff bristle brush and, before it is quite dry, rubbed off again with a stiff brush. A second coat is then applied, care being taken not to cover too large a space at once because at first it dries too quickly. Finally, the floor should be well rubbed with a woolen rag, which produces a nice matt polish.

Plastic slate, that is to say, moldable slate, is a mixture formed by combining about 1 part of coal tar and 4 parts of slate dust and is recommended for covering large wounds in trees. This mass must be of about the consistency of a not too thick glazier's putty, so that it can be balled and rolled out in the hand. Slate dust can easily be made by crushing small pieces of slate. The mass sticks to wood, to metal, to stone, and in fact to everything that is not greasy and closes every opening air-tight. Even if applied in a very thin layer, it hardens only on the surface, remains elastic, does not chip off in winter or run in summer. It is excellent as a tightening agent for water pipes, whether of wood, metal, or stone, for casks and many kinds of vessels. If the ordinary putty cracks away from the window panes of green-houses and hot frames the damage can be repaired without delay with the aid of this preparation. If extensive wounds on trees are covered with this mixture, which can best be applied by means of a knife or a flat stick, they will remain for years absolutely protected from air and moisture. The edges of the wounds heal over rapidly. If the black color is objectionable, sand, ashes, etc., can be scattered over it and pressed in.

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